American Cinematographer

International Journal of Motion Picture Photography and Production Techniques

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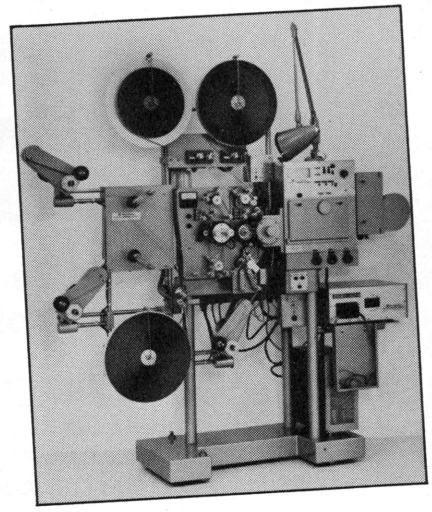

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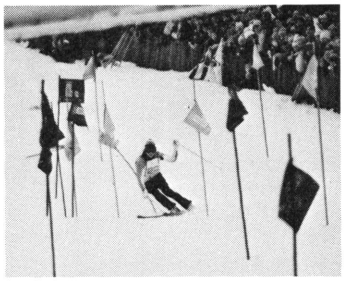
Gerry Souter, Senior Audio Visual Coordinator
Motorola Communications and Electronics Inc.

Since Motorola provided the two-way radios, pagers, and communications systems to the United States team at the 1980 Winter Olympics, Gerry Souter was sent to Lake Placid as a one-man-band required to shoot both stills and motion pictures of the events and Motorola's equipment in use.

"Naturally I looked for the most lightweight, quick-change cassette-load 16mm camera available," says Souter. "GSMO answered my needs in every way, and I was very pleased with the results of my choice.



"During two weeks of shooting, the GSMO was always ready to go. Much of my footage was shot at 64 fps, and the GSMO came up to speed instantly as the slalom skiers and bobsleds zigzagged past. The on-board battery never failed. Not even when the temperatures dipped way down into the teens.

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"GSMO's reliability is perfect for filming in the rugged conditions we have to work in: from the Winter Olympics at Lake Placid to the oil fields of Venezuela, including steel mills, fire departments, mountain top antenna sites, etc.

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International Journal of Motion Picture Photography and Production Techniques

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ON THE COVER: Detail of the lower eight months of the Cosmic Calendar from the COSMOS poster. Illustration by Adolph Schaller. The Cosmic Calendar compresses the Universe's fifteen-billion-year history into one year—each month representing a billion-and-a-quarter years of evolutionary history. At upper left, in May, or Milky Way Galaxy forms. Our solar system condenses in early September. The Earth is born in mid-September. The first life on Earth emerges in late September, here represented by the DNA helix. Life continues to evolve in later months and humans only first appear on December 31st, around 10:30 at night.

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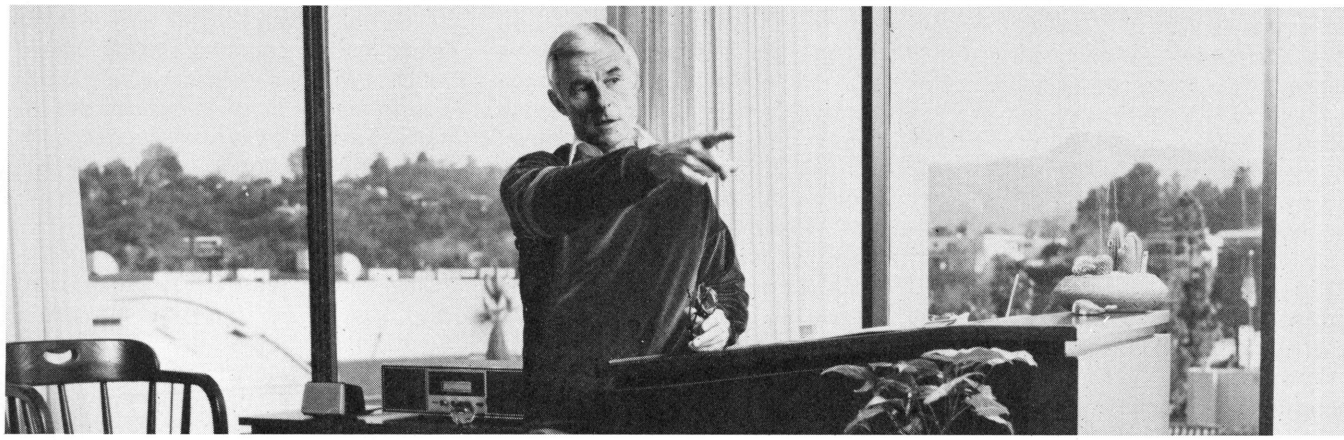
TINKER



"I think of our shows as films."

Grant Tinker, one of the founders of MTM Enterprises, freely confesses to being star-struck by those who create shows such as his highly regarded Lou Grant *and* The White Shadow; *and he has some engaging ideas about the rewards and responsibilities of working with top creative talent.*

"We're now dealing with an audience that has grown up with television. For them, television has replaced radio. The TV sits there humming in the corner, a little companion in the living room...maybe it isn't watched as closely as we think. This makes it tough on the sort of shows we do, because they have a beginning, a middle and an end. They're not just joke-laugh-joke-laugh. You have to pay attention.

"There is a certain kind of program I wouldn't be interested in coming to work to do. I *do* find it interesting to come to work to be associated with shows like *Lou Grant* and *The White Shadow.* The same goes for *WKRP in Cincinnati* and a new one to be seen in the fall called *Hill Street Blues.*

"All of them are done by first-rate creative people, and I really don't want to work with any but the best. All MTM has to offer is the product of these guys and ladies, when we can get them. So I spend a lot of my time trying to attract them to MTM and to keep them happy.

"I don't think television is as good as it can be. I understand why it has to be commercial and popular, but I'd like it to be better, if only because I, too, would like to watch some television. I'm the current chairman of the Caucus for Producers, Writers and Directors, about a hundred of us who account for most of prime time. We are all interested in improving the medium; one of the things we'd like is earlier announcement of network schedules each season to permit more lead time and, hopefully, a higher level of product.

"Also desirable are series commitments, as opposed to pilots, which may or may not be scheduled. It's not really a matter of money; there's a certain mental attitude that goes along with a series commitment. I'd also like to see the networks stay with slow-starting shows longer than they do. The history of television is full of shows that became huge successes after shaky beginnings.

"Inevitably MTM will make feature pictures, because we are a film company. I don't think of our shows as television; I think of them as films.

"I like the look of film; I find it pleasing. I imagine that we will go on making things on film whenever we have the chance. I wouldn't presume to legislate our use of film, because the people we employ know more about such things than I do. But since we go first-class in every way, I guess that's why they use Kodak film."

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CINEMA WORKSHOP

By ANTON WILSON

48FPS—A NEW STANDARD?

There has recently been some new experimentation with frame rates higher than 24fps in order to achieve sharper and higher quality images. Some of the proposed alternatives are seriously attempting to challenge the long incumbent 24fps. In light of this renewed interest in higher frame rates, a discussion of the topic seems appropriate.

The physiological phenomenon of "persistence—of-vision" is largely responsible for the existence of motion pictures. The human visual mechanism retains an image for a fraction of a second, thus enabling rapidly changing successive images to blend into a continuum. It was found that the perception of continuous motion could be achieved with frame rates as low as 12fps, but the effect was not natural. At frame rates of 16 or 18fps the sensation of motion becomes more natural and at 24fps the sensation of continuous motion is, for all intents and purposes, complete. The current evidence suggests that frame rates higher than 24fps will *not* significantly improve image quality in terms of the persistence-of-vision phenomenon. However there are other factors that enter into the discussion.

While 24fps is sufficient to achieve the perception of continuous motion, it still suffers from a prominent "flicker motion". This is due to an interesting phenomenon called the "critical flicker frequency" (CFF). The CFF is the frequency at which a pulsating light source or image appears continuous. Specifically, consider a rotating disk that is half-black and half-white. The disk is covered, with the exception of a small window. As the disk rotates, the window appears successively black, then white, etc. As the disk spins increasingly faster, a point will eventually be reached where the eye can no longer perceive the changing tone and the window will appear a smooth continuous grey. This point is the CFF. While the CFF is dependent on brightness to a certain extent, the CFF at standard scale illumination turns out to be about 48 images per second. Thus, while 24fps is sufficient to achieve a continuity of motion, 48 images per second is necessary to remove the perception of flicker.

This last criterion is easily made with the twin-bladed projector shutter. Almost every professional projector has a double-bladed shutter; one blade closes the projector beam as the frame is being advanced, while the second blade merely interrupts the existing frame for a similar period of time. In essence, each frame is projected twice. The image rate is 48ips, while the frame rate is 24fps. Thus, the CFF of 48ips and the persistence of vision rate of 24fps are both satisfied. What then can be achieved by increasing the frame rate?

The 24fps frame rate with a nominal 180° yields an exposure time of about 1/50 sec. As any still photographer can tell you, this is a marginally slow speed, especially if any action is involved. Moderate action usually calls for at least 1/125 or 1/250 sec., while fast sports-type action usually demands a speed of 1/500 or 1/1000 sec. to assure a sharp image. In comparison, the 1/50 sec. cine exposure seems inadequate, to say the least. Frame-by-frame analysis of even the most simple actions will reveal a blurred recording at 24 fps.

A logical solution often suggested is a smaller shutter angle. A 90° shutter will provide an effective exposure of about 1/100 sec. but this solution is unacceptable. It must be realized that the nominal 180° shuttered camera records only one-half of all the action. This may seem academic, but the camera misses half of all the action taking place in front of the lens. It chops time into little pieces of 1/50 sec. and then only records every other one on the frame, skipping the intervening pieces of action. The shutter blade on the projector is much smaller, as the projector pulldown is much quicker than that of the camera. In broad relative terms, the projected image is almost "on" continuously. Thus a picture that really only captured 1/48 sec. of action is projected on the screen for almost a full 1/24 sec. is meant to represent a full 1/24 sec. of action. While this seems to be acceptable to a greater or lesser extent, the 90° shutter situation is not. The 90° shutter only captures 25% of the action and totally misses the other 75%. It chops time into pieces of about 100th sec. duration, recording every fourth piece and skipping the other three in between. When projected, this little piece of action appears on the screen for almost a full 1/24 sec. and is made to represent a piece of time four times longer than it really is. The eye is asked to fill in the 75% missing action while given only the 25% that the image actually captured. Clearly the eye rebels. While the images will be sharper due to the faster shutter speed the results are very jerky and strobescopic. The results become increasingly aggravated with progressively shorter shutter angles.

The 48fps proposal incorporating a nominal 180° shutter appears to be a viable solution. The 48 fps rate provides a shutter speed of 1/100 sec., yet still captures 50% of the action. Each frame is much sharper, due to the increased shutter speed, yet there is no tendency to strobing that is associated with the 90° shutter. Moreover, proponents argue that despite the fact that 24fps is theoretically sufficient, the 48 fps rate also provides a smooth and more natural sensation of motion.

The results speak for themselves. Almost everyone who has previewed these new systems have raved about the superior quality of the images. Yet the system has its obvious drawbacks. Film and processing costs double, film magazines become effectively half the normal capacity necessitating twice the number of magazine changes, and the effective speed of the film is essentially halved. Is the increased quality worth the price? Unfortunately, most people in the front office will probably answer in the negative.

An interesting point to ponder is the coupling of 48fps frame rate to the TECHNISCOPE format. Costs and magazine capacities would remain the same as standard 24 fps. Only the effective film rate would still be reduced. However, I would be inclined to believe that anyone attempting to achieve the increased benefits of the 48 fps rate would not want to compromise the negative area of the image. Maybe this would be a good time to introduce the very practical 1:1.85 three-perf pulldown with a 48 fps frame rate. This would provide the full 1:1.85 negative area, the full benefit of the 48 fps, yet with only a 50% increase in cost and only a 33% reduction in magazine capacity. Time will tell. ■

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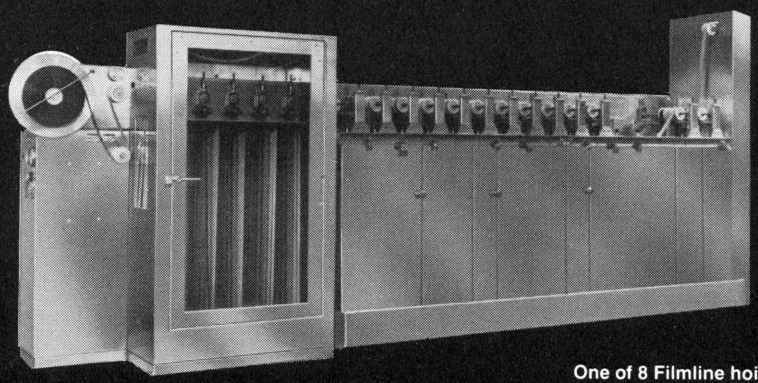

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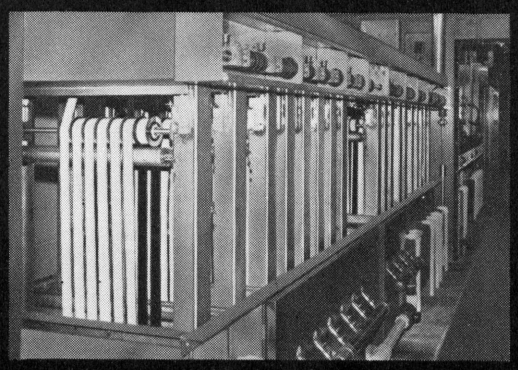

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PRODUCER/DIRECTOR ERIC WESTON FILMS

"Evilspeak"

Producer/Director Eric Weston lines up a shot with Director of Photography Irv Goodnoff on the set of "Evilspeak".

"Evilspeak" is a tale of the hellish terror let loose when a tormented boy-genius programs a sophisticated computer to summon and direct Satanic forces in a master stroke of terrible vengeance. It could have been just another 'horror' picture . . . but the skilled and sensitive direction of producer/director Eric Weston imbues its scenes with electric tension and extraordinary impact. That very special quality has come to be expected in Eric Weston's work. Through the depth of his own acting experience, Weston is able to project himself 'inside the actors' heads' to draw from the performer and the camera everything the screenplay will allow, *plus* a significant bit more. Call it 'instinct' or 'talent', if you will, but the fact is that it takes a lot of years of study, training and grinding hard work in live theater, TV and motion picture productions to mold and develop the exceptional professional capabilities of such a filmmaker. His considerable contributions to both the scripting and filming of this currently-shooting tale of occult deviltry have invested it with remarkable visual imagery and scope. We're certain that the industry is going to take increasingly sharp notice of the outstanding productions of Eric Weston from here on.

"EVILSPEAK"
A Coronet/ESP Production
Executive Producer: Sylvio Tabet

PRODUCER/DIRECTOR..... ERIC WESTON
ASSOC. PRODUCER ..... JERRY HOPMAN
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Still photography by James Michael Paris

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THE BOOKSHELF

By GEORGE L. GEORGE

THE REFERENCE SHELF

Published under the auspices of the American Society of Cinematographers and compiled by George Kent, MOTION PICTURE AND TELEVISION DICTIONARY ENGLISH-RUSSIAN, RUSSIAN-ENGLISH satisfies a conspicuous need. Some 600 pages containing over 13,000 entries that describe current techniques and equipment, Kent's eminently serviceable dictionary displays abundant evidence of having been thoroughly researched and checked with both U.S. and U.S.S.R. technicians. (ASC, Box 2230, Hollywood, CA 90028; $15. + $1 handling).

A boon to the advertising and sales branches of the film industry, Donn Delson's DICTIONARY OF MARKETING AND RELATED TERMS IN THE MOTION PICTURE INDUSTRY covers in sweeping fashion film and television industry terminology. Clear and literate definitions enhance the usefulness of this unique lexicon (Bradson Press, 120 Longfellow St., Thousand Oaks, CA 91360; $7.95).

In MULTIVISION, John Lewell describes current equipment and techniques that have improved audiovisual presentations in original and stimulating ways. These attention-getting devices based on essentially technological methods are surveyed, described and fully appraised in this illuminating volume (Focal Press $34.95).

Non-professional filmmakers eager to upgrade their skills will profit from the case histories discussed by J. David Beal in ADVENTUROUS FILM MAKING. Following a survey of available equipment, Beal relates the creative experiences of 14 award-winning amateurs (Focal Press $27.95).

Costume designers of the film/TV industry are provided valuable data in 3 recent volumes. Janet Arnold's A HANDBOOK OF COSTUME is a useful guide to bibliographical source material on wearing apparel, supplemented by relevant information on paintings, sculpture, tapestry, etc. (Phillips, 305 W. 86 St., NYC 10024; $25/12.95). Anne Hollander's SEEING THROUGH CLOTHES is a knowledgeable and informative text on the changing fashions and tastes of Western culture and its precursors (Avon $8.95). Michael Colmer's WHALEBONE

TO SEE-THROUGH deals with ladies' undergarments and their often startling evolution (Barnes $9.95).

★ ★ ★

GENRES AND TECHNIQUES

Cartooning in all its historic and artistic variations is comprehensively summed up in Maurice Horn's superbly researched work, THE WORLD ENCYCLOPEDIA OF CARTOONS. From a thoroughgoing survey of film animation to pertinent political drawings, this substantial 2-vol. set covers both the creators and their work in 1200 informative and abundantly illustrated entries (Gale $50/set).

A skillful survey of the American animation industry, Leonard Maltin's OF MICE AND MAGIC offers an engrossing picture of its remarkable evolution. Lengthy filmographies, perceptive interviews of leading craftsmen and superb illustrations add up to a well documented and thoroughly entertaining volume (McGraw-Hill $19.95 to 12/31/80, $24.95 thereafter).

In THE AMERICAN ANIMATED CARTOON, Gerald and Danny Peary offer a stimulating anthology of authoritative writings assessing the contributions of many animation studios and individual artists, scrutinizing the technical proficiency, historic development and social impact of a popular genre (Dutton $10.95).

A nostalgic and naive look at the Hollywood of a generation ago, SCREEN GREATS, edited by Bob Patrick, indulges common cravings for the sensational—and often fictitious—revelations of movie stars' private lives (Starlog $2). More of the same appears in HOLLYWOOD IN THE 40S, a collection of the stars' allegedly by-lined stories, but actually penned by the studios' indefatigable publicity departments (Ungar $9.95).

From Lassie to King Kong, performing animals and their trainers are engagingly discussed by Edward Edelson in GREAT ANIMALS IN THE MOVIES. His book describes in knowing and entertaining fashion training methods, "acting" lessons, as well as scale model and animation technology (Doubleday $7.95).

Names and addresses of some 3000 world-wide celebrities are listed by Michael Levine in HOW TO REACH ANYONE WHO'S ANYONE, enabling mail to achieve safe, but sometimes indirect, delivery (Price/Stern/Sloan $4.95).

★ ★ ★

TELEVISION TOPICS

A comprehensive reference work, Vincent Terrace's COMPLETE ENCYCLOPEDIA OF TELEVISION PROGRAMS 1947-1979 covers all regularly scheduled shows of the period in a well researched and methodically organized volume. Nearly 3500 network and syndicated programs are included, providing storyline information, cast-&-credits listings, running dates and times, and other relevant data plus a complete index (Barnes $10.95).

Funny as well as revealing of prevailing television quality standards, THE WORST TV SHOWS EVER is a provocative compilation by Bart Andrews and Brad Dunning of some 30 programs that—in the authors' view—reached the ultimate in bad taste, mental retardation, vulgarity and all-around worthlessness. One may dispute some of the choices, but the book is mostly on target (Dutton $6.95).

An exhaustive market guide to British television, edited by Angus Robertson, VIDEO YEARBOOK 1980 provides detailed information on systems, products and services available to the world trade. Equipment manufacturers, distributors and import/export firms, some 800 in all, are listed (Sterling $37.50).

The extent of television's surrender to commercial interests is analyzed in historic perspective in Lawrence Bergreen's valuable and engrossing survey, LOOK NOW, PAY LATER. Holding this situation responsible for the general mediocrity of programming, Bergreen sees in new technologies and new distribution systems the basis or a possible revival of the medium (Doubleday $12.95)

A warning of a potential threat by big business to the public airing of differing opinions is voiced by Benjamin M. Compaine in WHO OWNS THE MEDIA?, as he examines the concentration of ownership in the mass communications industry. This collection of articles by media experts pointedly contrasts the profit-making nature of the industry with the public service they must, by statute, perform (Harmony/Crown $15.95/8.95).

Techniques of television newsgathering, as compared with print media, are informatively discussed by Herbert J. Gans in DECIDING WHAT'S NEWS. Choice of stories to be covered, dispatching of crews, location taping, editing the segment and fitting it into the newscast are vividly described, as are the hectic pace and constant job pressures (Vintage $5.95). ■

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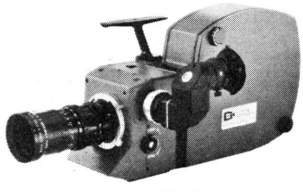

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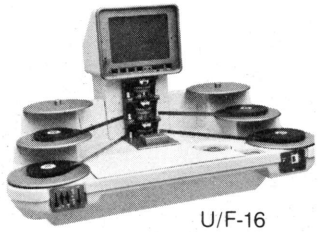

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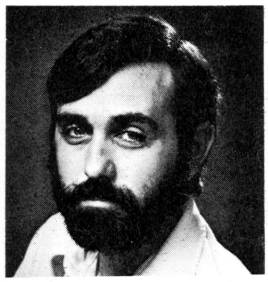

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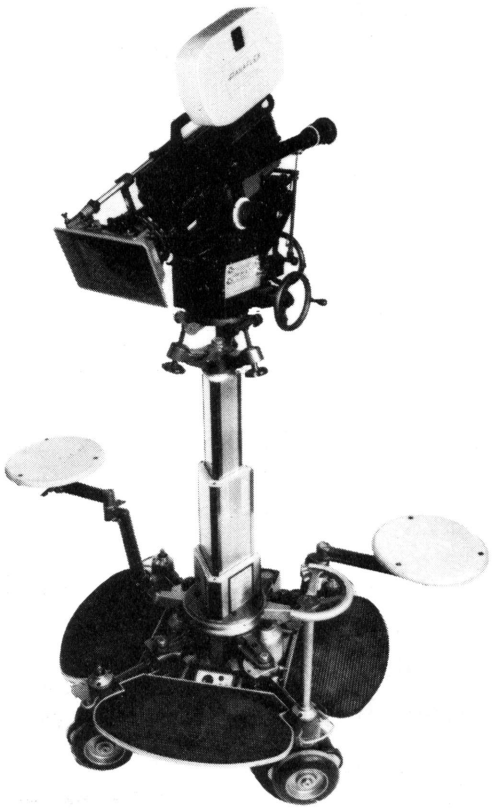

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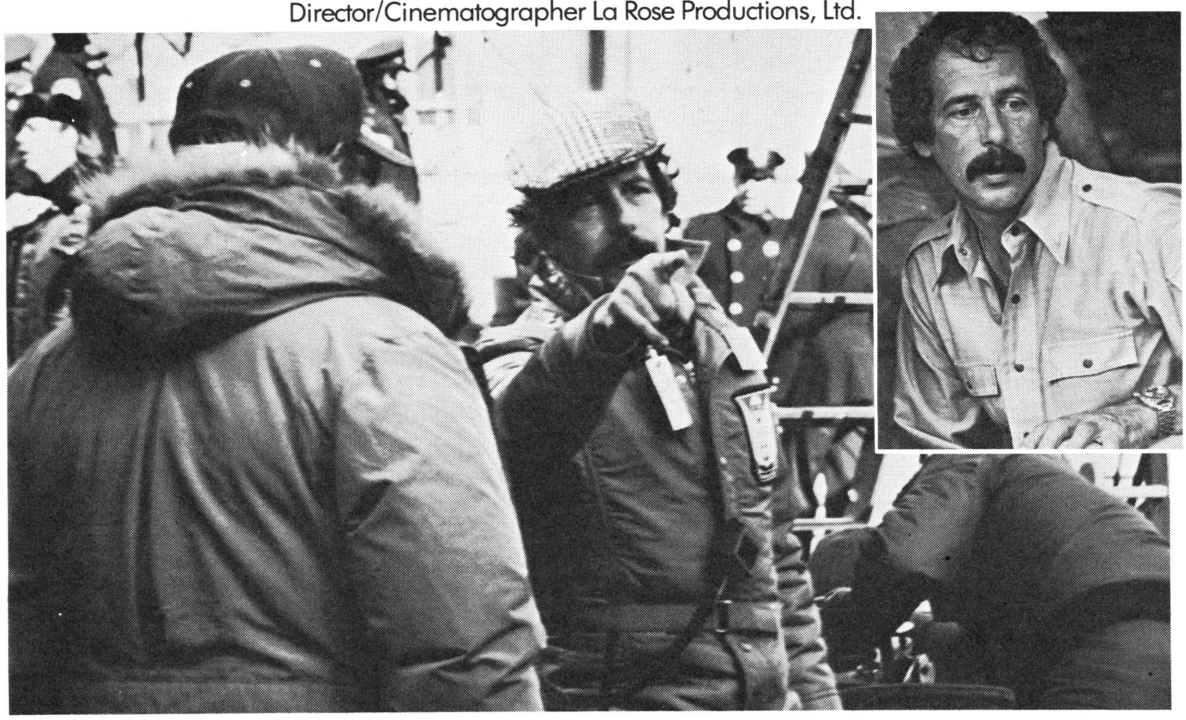

"Wherever I am—whether it's San Francisco or Indiana—I keep in touch with TVC. It's an on-going dialog. When I was shooting in Texas recently for eight solid days, I was on the phone every morning at 7 a.m. to the timing department at TVC, to check up on my dailies.

"Working in the demanding dual role of director/cinematographer, it's essential for me to have technical assistance I can truly rely on. TVC would give me a pretty good idea of how things were looking. On the basis of their comments I could judge if I needed to give a little more on the negative or make any additional corrections. I would go back to my shoot feeling more comfortable because I knew I wasn't working in the dark. TVC was on the job, watching over my dailies. And, sure enough, everything was right on the button.

"I have a great relationship with TVC—almost like family. I've used that lab for fifteen years because I like their work and I like their attitude. I know the look I want and I'll try anything to get it. I'm always pushing the film to a point where it just can't go any further, always trying to get as much out of the film as possible. And TVC will back me all the way. TVC simply makes my life a whole lot easier.

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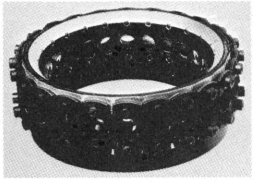

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Great Britain

August 4, 1980

Herewith my qualifications, or lack of them, for making the sweeping generalisations on the next two pages.

Before becoming a cameraman, Nick Downie was a professional soldier for 6 years, which included 3 1/2 years in the SAS and active service on four campaigns. He is now an independent film-maker, specialising in guerrilla warfare.

So far he has spent 3 months with the Pesh Merga guerrillas in Iraqi Kurdistan, 3 months with the Eritrean guerrillas, 6 weeks with Polisario in the Western Sahara, 6 months with the Rhodesian Army and, most recently, 4 months with the guerrillas in Afghanistan.

In 1977 he won The Royal Television Society's News Feature Award for Polisario, and in 1978 he won it again for Rhodesia. The Rhodesia film was also the ITV Nomination for Monte Carlo.

Overheard on location : German sound-recordist, pointing at my Aaton, "What sort of camera is that?" German cameraman, "The best".

On my first day in Afghanistan we marched for fifteen hours non-stop. It was August and very hot. We crossed two passes — a total of 5000 feet going up and 6000 feet coming down. Throughout that time my Aaton perched comfortably on my shoulder, and I know of no equivalent camera which is so easy to carry. It is a tribute to the Aaton's ergonometric design that I ended the day just with blisters and not a heart attack.

Aaton magazines are child's play to load and unload. Too many other cameras leave you struggling in the changing bag with a roll of film that is liable to uncoil as it comes off the spindle. Normally that only results in irritation all round and a few minutes' delay, but get caught like that as a helicopter gunship clatters over the brow of a hill and the delay is liable to be permanent.

It is a common misconception that the camera best-suited to filming a war should be built like a tank. The trouble is, those cameras make a noise like a tank on the sound-track. Even in the middle of a battle there are moments of quiet when a well-blimped machine is just as important as on location in the home counties. One of the most valuable qualities of the Aaton is its silence.

When filming a battle, there is no worse experience than seeing one's companions making a hasty exit. Men carrying just a rifle and a bandolier can disappear with unnerving rapidity, and it is a grave disadvantage to be left lugging a heavy or unbalanced camera, trailing battery cables. The Aaton is light, neat, and easy to run with, even with legs that are turning to jelly.

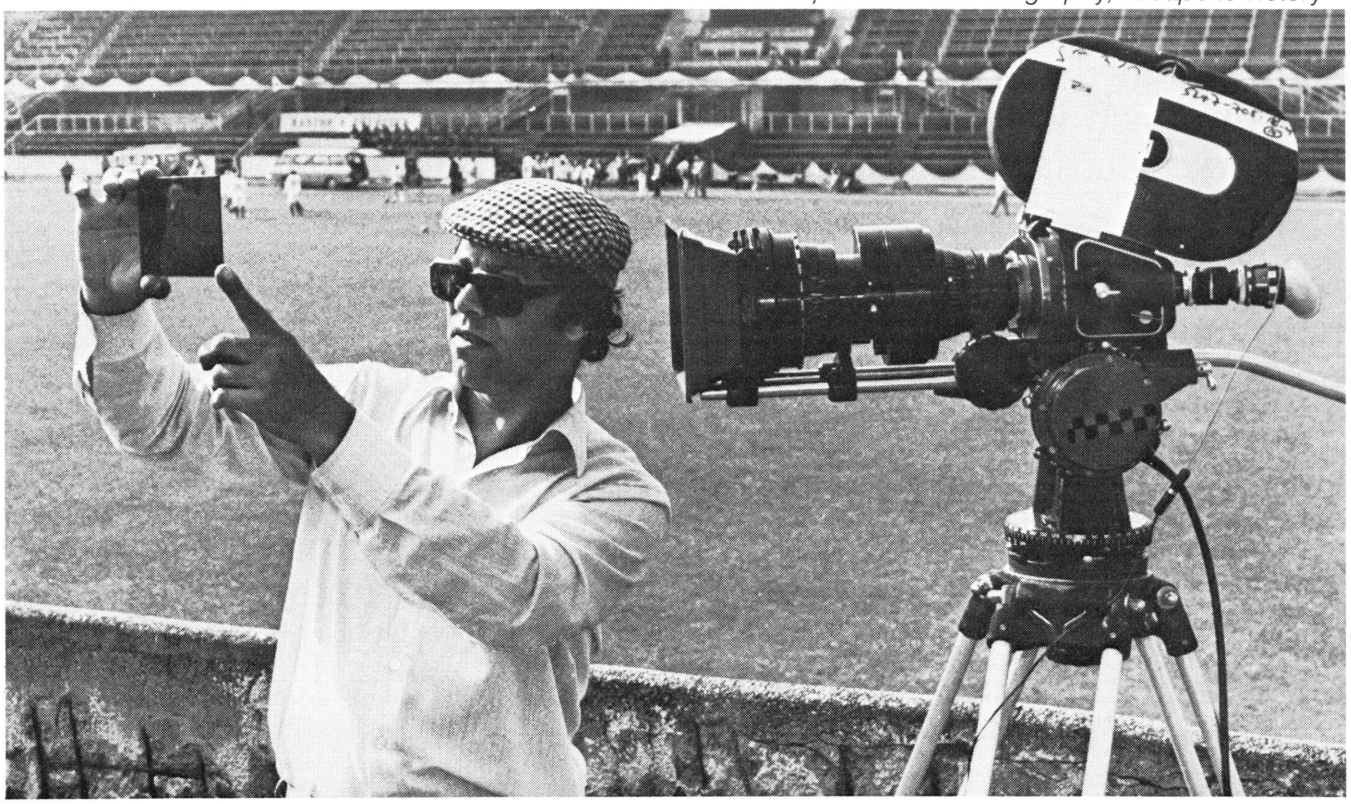
With all the other cameras I know, the day you drop the thing in a river in the middle of nowhere, is the time to go behind a rock and quietly cut your throat. With an Aaton you simply produce half-a-dozen Allen Keys, strip it down, and give it a good clean. Blow the electronics, and it takes five minutes to replace them with a set of "Red Spares".

When you're freelance, and about to invest thousands of hard-earned pounds in a camera, you think for a long time before chatting-up the bank manager. I bought my Aaton after I'd tried all the other comparable makes, usually under fire, and the Aaton was the only one which met every specification.

An Aaton is like a good woman : some of the best qualities only emerge after prolonged acquaintance.

"I always use Tiffen Filters for their consistency and reliability. I know that I will always come home with the results I want."

Ron E. Collins, *Director of Photography, Escape to Victory*

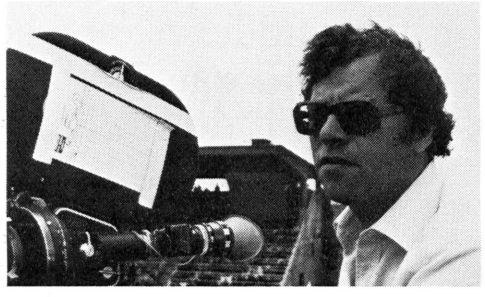


"Shooting John Huston's Escape to Victory presented a great many challenges, and Robert Rigor, director of the sporting sequences, wanted the best crews he could find and the best equipment he could get. This included Tiffen filters.

"When you're shooting a major feature, it's important to know that your equipment is utterly dependable. And that's the great thing about Tiffen filters. They're rugged. They're reliable. Precision-made, they're built to stand up to all kinds of weather and to just about any shooting conditions.

"They always perform well. The colors are constant. They do not vary. And I can choose from over 2,000 different filters and lens accessories. I know for a fact that there are Tiffen filters to give me any effect I want to achieve from reducing glare to correcting color balance.

"I've worked for British Movietone News for years as well as for documentary companies. And in the course of my career I have been involved with no fewer than 500 soccer matches, ranging from national events to Olympic Games coverage. I can truly say that Tiffen filters have helped me come up with winning footage."



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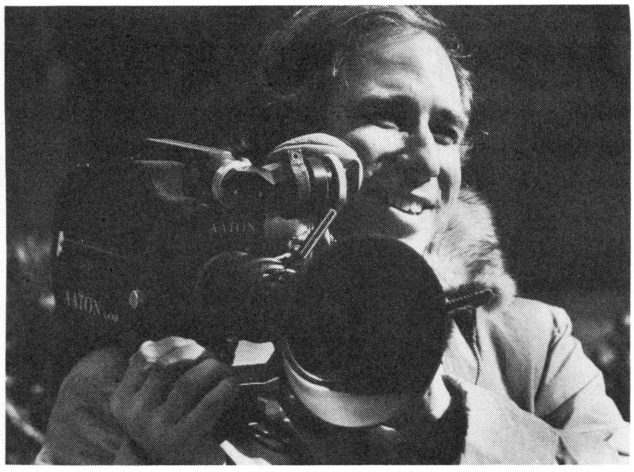
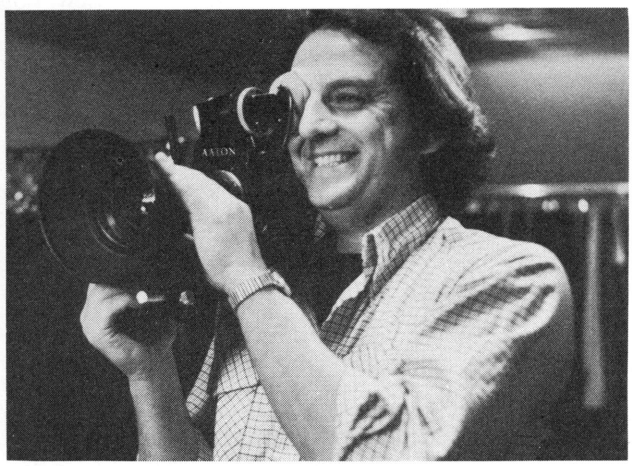


Dave Grubin on-location for "The World of David Rockefeller," the 90-minute documentary he produced for WNET's "Bill Moyers' Journal."

"The design of the Aäton LTR 16mm isn't just beautiful...it's thoughtful, too. They must have spent years analyzing the features active cameramen need. It's amazingly lightweight with a low silhouette and perfect balance, so it nestles softly and naturally on my shoulder. And it stays comfortable all day. I chose Aäton because it's as professional as you can get. And that's why I go to Zellan Enterprises for sales and service."

Greg Cooke filming another "60 Minutes" segment with his distinctive "shoot-from-the-hip style" of cinematography.

"60 Minutes is gutsy photojournalism at its rugged best, and the Aäton is making it even more exciting. The whisper quiet mechanism lets me film interviews unobtrusively in intimate settings. Outside, I can shoot comfortably holding the Aäton out of sight by my hip or balanced just by the carrying handle. And its engineering is as reliable as it is advanced. I brought the Aäton along as my sole camera to a shoot in the Saudi Arabian desert. It was like being in a sandblasting machine, but the camera held up perfectly."



Chuck Levey shooting a segment of CBS' "30 Minutes." Other assignments from the network include "60 Minutes" and CBS Reports.

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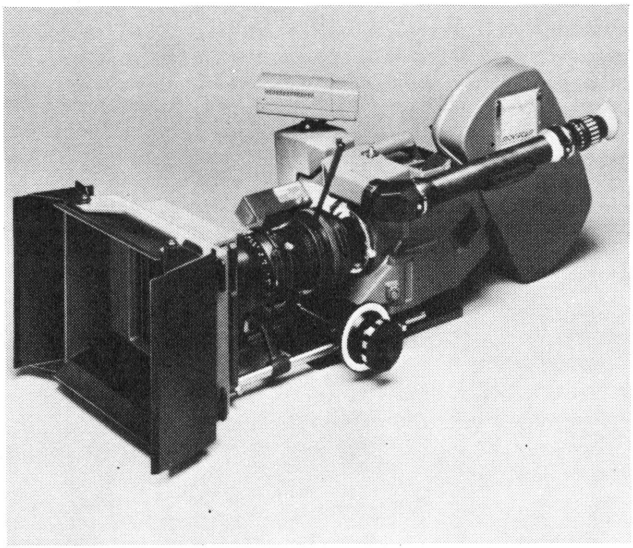

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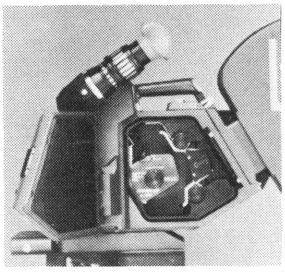

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Moviecam, Made in Austria

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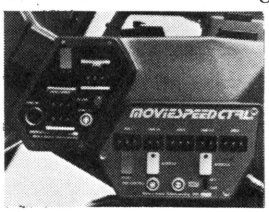
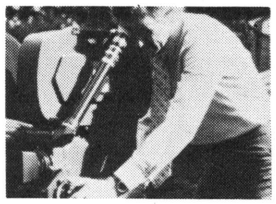
A microprocessor controls the drive motor. It even tells the built-in heating system when to function. Forward, reverse, raw stock footage and frame rates are digitally displayed. Plus a phase shifter that synchs the Moviecam to any TV monitor. The speed control allows the running speed to be changed at programmed rates during the shot. Exposures are automatically compensated.



Lens Compatibility

All the lenses you've carefully collected over the years and wouldn't dream of replacing are compatible with the Moviecam's bayonet BNCR mount.



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"COSMOS" — THE MAKING OF THE SERIES

Bigger than all outdoors, this ambitious 13-part series takes the viewer to the edge of the Universe and beyond in the realm of ideas

Dr. Carl Sagan, the distinguished space scientist and Pulitzer Prize winner, is the author and host of COSMOS, a thirteen-part television series devoted to what's out there—to astronomy and space exploration in the broadest possible human context.

Dr. Sagan will guide television audiences on a spectacular voyage through space and time to explore what he calls "the deepest connections of human beings with a vast and awesome universe in which we float like a grain of sand in the cosmic ocean."

A joint production of Carl Sagan Productions and KCET, Los Angeles, COSMOS will premiere in 1980 in the United States on the Public Broadcasting Service (PBS) and on other television systems throughout the world.

COSMOS is made possible by grants from Atlantic Richfield Company, the Corporation for Public Broadcasting, and The Arthur Vining Davis Foundations. The British Broadcasting Corporation and West Germany's Polytel International are co-producers.

Adrian Malone, executive producer and co-writer of COSMOS, was previously executive producer of the award-winning BBC television series *The Ascent of Man* and *The Age of Uncertainty.*

Through the lavish use of special effects and filming at more than forty locations on the planet Earth, COSMOS probes spacecraft missions of discovery to the planets, black holes, the origin of matter, the human brain, alternate universes, time travel, communication among the whales, the death of the sun, and life on other worlds.

COSMOS investigates Hindu cosmology, cosmic catastrophes, the Voyager interstellar message, Martian canals, robots, travel to the stars, cosmic influences on the evolution of life, the collisions of continents, sailing ship voyages of exploration, the deciphering of Egyptian hieroglyphics, the origin of life, contact with other civilizations in space, the birth and death of stars and galaxies, the interconnectedness of all living things, the future of the Earth, and the deepest questions concerning the origin and fate of the universe.

COSMOS embraces many sciences and cultures, providing a cosmic perspective for the planet Earth. A spectacular special effect, to be present in every episode, is the Cosmic Zoom, in which Dr. Sagan's spaceship will hurtle into clusters of galaxies, quasars, pulsars, supernova explosions, multiple star systems, the rings of Saturn, the surfaces of Mars and Venus, and home to a tiny world called the Earth.

The Cosmic Calendar is another special effect, in which the fifteen billion years of universal history since the Big Bang will be compressed into a single cosmic year. Dr. Sagan takes viewers "on a walk through this vast expanse of time, during which matter has evolved into beings with consciousness, able to understand the Cosmos."

In one of many journeys back into time, COSMOS recreates the glorious million-volume library and research institute of ancient Alexandria, center for the greatest minds of its time, and birthplace of many of the sciences discussed in COSMOS. "The destruction of that Library, which may have postponed the Renaissance by a thousand years," Dr. Sagan says, "is a lesson for us on the importance and fragility of knowledge."

COSMOS features more than seventy special effects sequences presenting the grandeur, scale, complexity, mystery, and order of the universe, revealing science as stranger and more tantalizing than anything in science fiction. These effects employ sophisticated model animation, back and front projection, Chroma-key, explosions, tank shootings, mattes and traveling mattes, cell and graphic animation, new technology effects using motion control systems for multiple layer compositing, the Magicam miniature matting device, thermography, specially commissioned astronomical art, micro and macro photography, and photomicrography for the treatment of the cosmos at the cellular and molecular level.

The lighting format for COSMOS has been orchestrated as though it were a musical score.

Dr. Sagan received the Pulitzer Prize for non-fiction for his book *The Dragons of Eden* which was for eight months on the *New York Times* best-seller list. He is Director of the Laboratory for Planetary Studies and the David Duncan Professor of Astronomy and Space Sciences at Cornell University, Ithaca, New York, where he also serves as associate director of the Center for Radiophysics and Space Research. He has extensive experience in the presentation of science on television, ranging from *Nova* to national news programs to the *Tonight Show.*

Dr. Sagan has played a leading role in the Mariner, Viking, and Voyager missions to the planets for which he received the NASA Medal for Exceptional Scientific Achievement in 1972, the International Astronautics Prize, the Prix Galabert, in 1973, and the NASA Medal for Distinguished Public Service in 1977. He was awarded the Joseph Priestly Prize "for distinguished contributions to the welfare of mankind."

Adrian Malone, executive producer and co-writer of COSMOS, has received the Peabody, Academy, and two Screen Writer's Guild Awards in recognition of his extraordinary career in producing, writing, and directing television documentaries. Currently he is also a lecturer at the University of Pennsylvania in the Department of History and Sociology of Science.

In the interview for *American Cinematographer* which follows, Mr. Malone discusses the evolution of the COSMOS series and gives a candid behind-the-scenes appraisal of the challenges that had to be met and the techniques employed in meeting them:

QUESTION: Can you give me some idea of how COSMOS came about—its genesis as an idea and your basic approach to handling such a vast subject for the television medium?

MALONE: The thing is that Michael Gill and I did, in a way, pioneer or invent this idea of the creative documentary—the longish series which takes a whole view of history or a whole view of a number of disciplines and tries to make a synthesis of those disciplines. Synthesis is the important word for us really. And I never do anything unless it has a bearing on the history of ideas. My litmus paper for going in is to say, "Well, is this going to be an education for me?" If it isn't, then I don't do it. When we first started on this, when I got the first rough drafts of Carl Sagan, et al., put together, I didn't like it at all and said so. Because it seemed to me to be very woolly. I had been the Senior Science Producer of the BBC, so I was very concerned that it didn't look, in my words then, "Hollywood". I've since revised my opinion of Hollywood, but at that time that word Hollywood was a pejorative term for glossy packages which, when you opened them, didn't contain anything very much. However, after some talk and some sense that Sagan and I would create this together, it

worked pretty well.

QUESTION: Did you approach it as a subject that was all of a piece or as 13 separate subjects bound together by a common theme?

MALONE: You can't approach doing one of these things like you would approach making a single film. There is no way you can do that. If you make a single film it is like making a Cellini saltcellar. It does one thing, it is a single shape, it has an integrity and a beauty of its own, you know. It's like the hull of a yacht. It's just very beautiful and you spend a lot of time honing it and shaping it, but it does one thing: it cuts through the water. Whereas, when you are doing one of these projects, you are dealing with the very stuff of complexity. You are dealing with what is in the human mind and the human mind is, unfortunately, very complex. So what you've got to think of is a very great deal of subject matter across a very wide area, making sure then that the connections you make of that subject matter don't end up with a camel, because it is very easy to make a mosaic. The problem is to make a mosaic that looks like a picture when you stand back. You can get all your little pieces together and you think they are terrific, marvelous. Then you put them together and they are just a mess. It's like mixing every color in the spectrum; you can mix them and pour them into water and the only thing you ever get is dirty brown, no matter how you do it.

QUESTION: Does that mean, then, that you did actually have to approach COSMOS as 13 separate programs?

MALONE: Well, the aim was not to make 13 magazine programs. The intellectual side of it has to be very firm before you start thinking imaginatively, before you start thinking of the visuals and how you will illustrate it. The next thing is to think, "Well, what sort of man is this who is going to be intellectual mentor? What is his personality? What is his background? What sort of vehicle must one create around him which will sit with him." You know, there are some people you can put into a Rolls Royce and some people you can put into a Pinto and some people you can put into an old steam train and some people you put into an airplane. It depends on the way they do things, the way they go about it. Sagan seemed to me to be a man who was young enough not to be the pontiff. He's also a great popularizer, so therefore, one wanted to have a series which was very popular, which was glossy, which had the dollars on the screen. Then the next thing to say was that this is a particularly American preserve—space—and, therefore, it should echo that. It should obviously try to use many of the techniques and, in fact, invent techniques which are particularly vested here in Hollywood. I think the program is politically very important. I mean, if this succeeds, then it will prove that the sort of intellectual colonialism of the BBC is finally over and that America can actually produce these sorts of things.

QUESTION: Did you feel initially that the special kind of talent that it would require was lacking in Hollywood?

MALONE: Obviously the talent is here, but it's always been used in different ways, in other ways. It's been used for cops and robbers or for variety shows or for very fine feature films, but in television you've never had the sense that there can be a mixture of entertainment and education. That's not easy. So, I knew we had to start off with something I always start of with, which is to say, "What is the intellectual content? How does that knit together? Does it have an integrity?" After that, since this is about space and since it is about the receptical of nearly all imagination in the young, which is out there as opposed to here, then it should be very imaginative. There should be the use of a lot of investment in imagination, as opposed to money or the way things were always done. So it had to have special effects, it had to have studio, it had to have location. I wanted desperately to get a sense of history into it because that's something, also, I believe, lacking in programs here—and that's important.

QUESTION: In concrete, practical terms, how did you decide to go about doing that?

MALONE: I decided that the golden rule was to let the imagination really go and that, in this way, we would be sure to find or invent ways to do it. I told myself: "We are in Hollywood, we are in the mecca, the home of invention, as far as the media, the screen, is concerned. Surely we can invent ways to do what we want to do. We should not be limited by the technology that is here, or by the ways of doing things that are here." That was one rule. The other rule was to find a team—since I always work with teams—a team which would be able to do this. It would have been very easy for me to sort of ship the thing from Britain, in a sense, but I don't think we'd have got the product. And I also knew that there was an enormous talent here. The problem was to find it. You know, when you put together a very complicated machine tool, there are a lot of parts to it. All of those parts have a speciality. If you took any three of those parts, they would do some sort of job. If you take the seven or eight or nine or thirty parts that make that machine tool up, they are all fine pieces of work in themselves. They all have their talent, but when you put them all together, the sum of those parts is much greater than the number—and that's the secret of putting a team together.

QUESTION: In assembling such a team, what is the primary qualification that you look for?

MALONE: The basic golden rule is to find good minds. Good minds are always imaginative. There is no such thing as an unimaginative good mind, I don't believe it. When people say, "I'm a mathematician, but I know nothing about history," that's bull; that's just rubbish. So the second thing was to make sure that the various special talents could mold into a bigger picture. If you are looking for producers you are looking for people basically with judgment. If you are looking for directors, you are looking for people with an eye and an elan, a courage, and if you are looking for a researcher, you are looking for somebody who never lifts his head up when he is talking to you. His head is always totally buried in material.

QUESTION: How did you go about finding the right individuals to build your team?

MALONE: I interviewed a very great number of people to put the thing together. Before that, however, Sagan and

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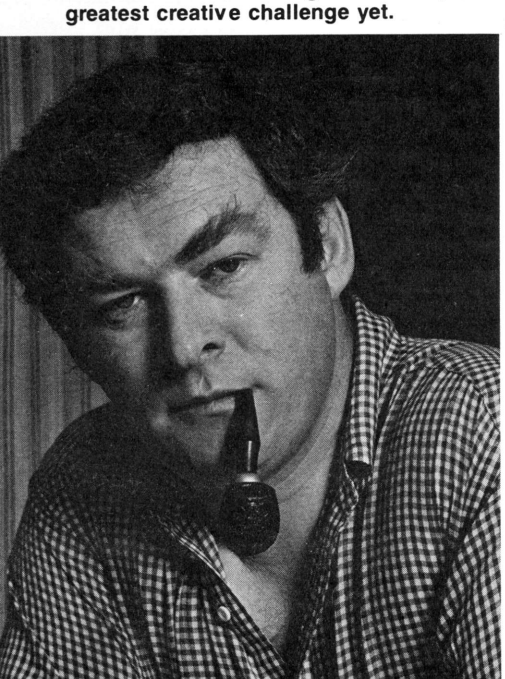
Having left behind a distinguished track record at the BBC, COSMOS Executive Producer and co-writer Adrian Malone moved to KCET, Los Angeles to accept his greatest creative challenge yet.



THE SPACESHIP OF THE IMAGINATION

"Constructed of light and powered by music", this magic ship takes the audience on a mind trip through the far reaches of deep space

By ROB McCAIN
Director

The cornerstone of the COSMOS series is a "spaceship of the imagination" through which we gaze at the wonders of the universe. Rather than undertaking our journey in a spaceship of the future, complete with the trappings of futuristic technology, Executive Producer Adrian Malone dreamed at the outset of "a ship of the imagination, constructed of light and powered by music". He was determined to create a visual and aural presence that would allow the viewers' imaginations to be opened to the power and majesty of the Cosmos. Such a vehicle had to have grace and texture, and create a feeling of peace and security in the audience. Because the programs would be seen on a small television screen, we had to lure the viewers into their sets. Rather than just observing, they had to participate in the experience.

After making a visit to the Air Force Academy Chapel, Malone decided that the spaceship should have a similar cathedral-like design. Such architecture would give the ship the required feeling of reverence and serenity. Art Director John Retsek immediately began making the first in a series of several scale models of the set. With the basics for the interior design decided upon, attention now turned to consideration of the exterior view of the ship. Malone wanted the outside of the ship to have an organic feel.

He chose the simplicity and elegance of a dandelion puff-ball as the ship's exterior representation. A brilliantly glowing dandelion, constructed of spines of light, would sail through space leading us on our voyage of imagination.

The main purpose of the ship was to serve as a frame for our visual effects. The centerpiece would be a 12- by 14-foot window onto space through which our cosmic effects would be viewed. The effects would take us from the outer edges of the known universe to our own solar system. We would visit galaxies, nebula, stars, and planets on a survey of some of the objects which make up the Cosmos.

Finding a projection system which could meet our rigid production requirements proved to be much more difficult than we originally anticipated. There was the physical constraint of shooting on a 60- by 120-foot stage with a grid height of only 23 feet. Once the 42- by 86-foot spaceship set was built on stage, little space would be left for projection equipment. The technical requirements, however, presented the most difficult problems. Whatever system we chose had to be compatible with the 30 frame-per-second scanning rate of television. In addition to that, the projected image had to be rock steady. Image stability was of paramount importance if our journey through the Cosmos was to be credible. The final requirement of the system was that it had to produce an image of acceptable resolution and brilliance. The spaceship would be shot on videotape, and the characteristics and limitations of the video cameras had to be given constant consideration.

The search for a system lasted well over a year. We first looked into video projection. However, it proved to be out of the question because of resolution and throw distance problems. Rear projection was dismissed because we lacked the required throw distance on our stage. If film projection were used it would have to be normal theatrical front projection with the unit installed on top of the set.

The physical problems, while difficult, were the easiest for us to solve. The technical problems, at least for a while, seemed insurmountable. Existing pin-registered movements were unable to reliably handle the required 30 frame-per-second projection rate. To compound the problem, we ran into serious difficulty with the projection shutter systems. An image projected using a process projector had serious ghosting problems when photographed with a television camera. One after another projection specialist told us that a system which could meet our requirements did not exist. Furthermore, there were serious doubts that such a system could be designed and constructed without long-term research and development. Even that, we were advised, was a shot in the dark.

With film projection hopes doubtful, we decided to once again consider electronic Chroma-key. It had been dismissed earlier because its use would have locked us into static camera shots. However, tracking Chroma-key systems had been recently marketed which used a small microprocessor to track the blue screen as the camera on stage moved. The keyed image was then automatically adjusted to correspond to the camera angle.

But tests proved the system to be unsatisfactory for our use. An inherent delay time in the speed of the electronic pulses which control the system caused the inserted image to jump in the composite. We were now back at square one. We had consulted with projection experts in the U.S., Canada, and England and still had no way to project our visual effects. The only option left was to undertake the design and construction of a new system ourselves. Our technical consultant, Charles Lux, undertook supervision of the project. The resulting system proved to be everything we required and then some.

As I indicated earlier, serious attention was being given to the operating characteristics of the television cameras which would be used to shoot the spaceship. We knew that the brilliance of the projected visual effects could be diluted once we lit the set. It was decided that the newest low-light-level cameras would be required if we hoped to get maximum quality. KCET purchased new RCA TK-47 cameras which would allow us to shoot with as little as 15 footcandles. In addition, they had an anti-comet tailing feature which would minimize the video lag inherent in electronic cameras.

We now had set design in the works, our fingers crossed about a projection system, and new state of the art cameras on order. Attention now turned to lighting. It was felt that to use the spaceship to its fullest potential it should be approached as more of a theatrical experience than as a television show.

If we could create an experience on stage that was captivating to Carl Sagan and the production crew, then we believed we could achieve a much more total experience when it came to translating the images into television pictures. Environment and atmosphere would be given primary attention; production technique would follow. In keeping with our theatrical concept, we decided to look for a lighting designer with a concert and stage background. After interviewing a number of lighting designers, I found our man in Kirk Morris. He had imagination along with incredible energy and enthusiasm.

We had two major requirements for the lighting. It had to give the ship a feeling of being constructed of light, and it had to create the impression of movement through space. To help achieve the first effect, we decided to cover the structure of the ship with a translucent plastic skin. When lit from behind, it would give us our ship of light. Its translucence would also

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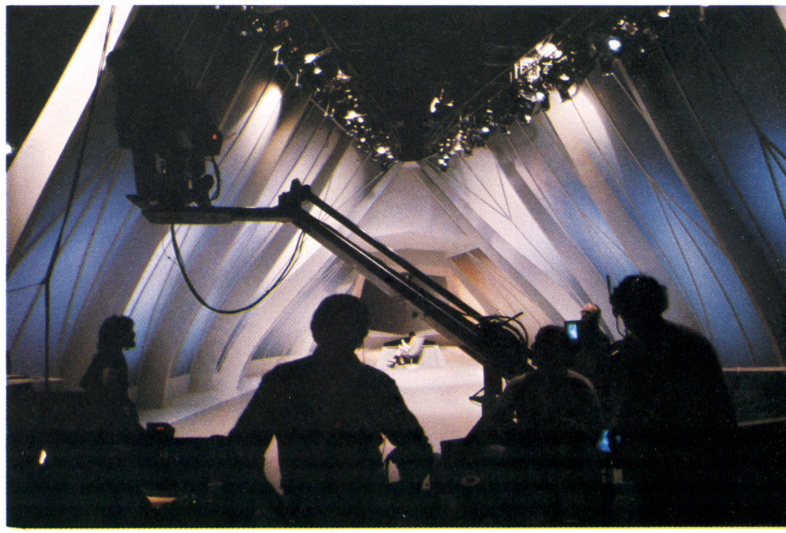
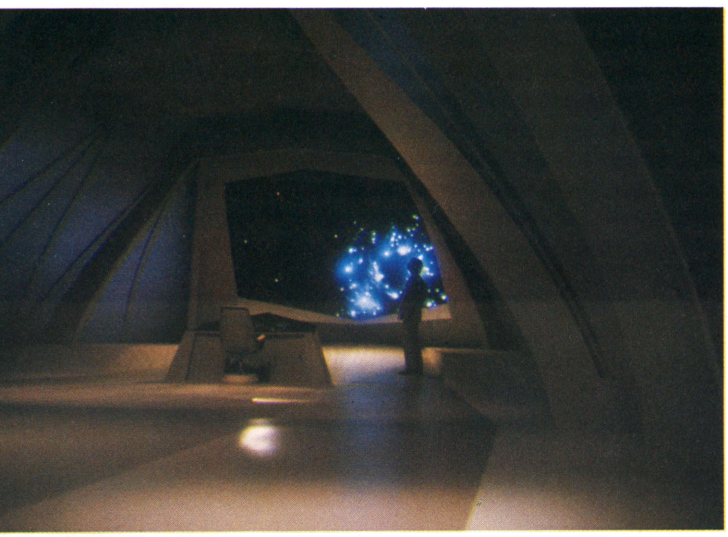
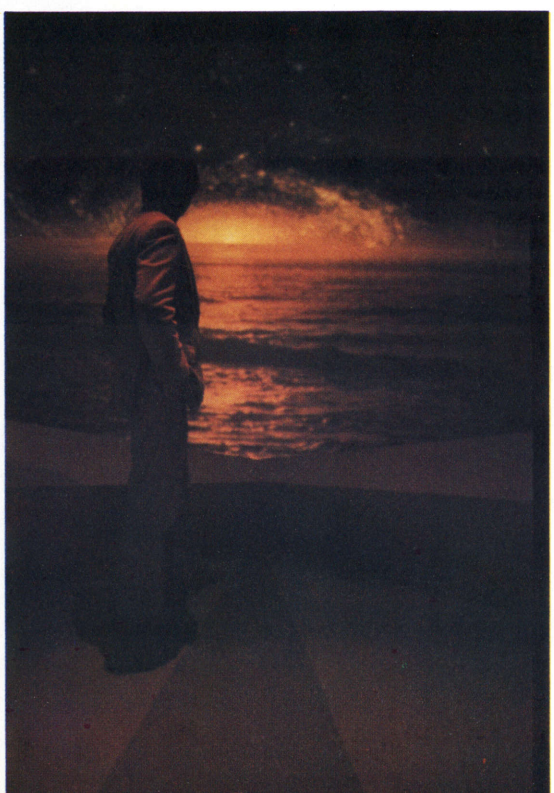


(LEFT) Shooting a globular cluster in the spaceship of the imagination. (RIGHT) A Lighting rehearsal in the spaceship studio. Lighting designer Kirk Morris broke the ship into six areas along each side and down the interior of the set. These 18 lighting areas allowed him to "walk" the light down the ship as it passed objects in space. To accomplish this he used 252 lighting instruments, each on its own dimmer.



(LEFT) Flying through the Pleiades in the Cosmic Zoom. (RIGHT) The spaceship approaches an exploding radio galaxy. The lighting had to give the ship a feeling of being constructed of light and it had to create the illusion of movement through space. To help achieve the first effect, it was decided to cover the structure of the ship with a translucent plastic skin, lit from behind. The job of the Lighting Designer was to make the entire ship fly.



(LEFT) Carl Sagan, standing in front of the spaceship window, watches a galaxy rising over the ocean of some far distant planet. (RIGHT) Carl points out our relative position in the Milky Way, as the ship approaches it edge-on.

"COSMOS" CINEMATOGRAPHY

Working long hours under difficult conditions and with many directors, camera crews roamed the world to shoot vital sequences for COSMOS

THE "COSMOS" CINEMATOGRAPHERS
By DAVID OYSTER
Assoc. Prod. and Director

A series the size and nature of COSMOS relies heavily on the skills of its cinematographers in order to maintain visual style and continuity. We were fortunate in having two very good cinematographers on this series: Hilyard J. Brown of the United States and Chris O'Dell of England. Both of these men are broadly experienced and equally at home whether shooting hand-held in a rice paddy, or a mission control room, or perched atop a crane while filming with a full crew and period-costumed actors and sets, or working with elaborate camera systems for special effects shooting.

In selecting a cinematographer, it is hard to decide which good one to to use; there are so many. It is ultimately a question of the chemistry of the show and the people who are producing, directing, writing or appearing in it. In this case, the chemistry was good. All of the people involved in the project had made a major commitment of their time and efforts to it. We wanted cinematographers who were in a position to make a similar commitment. Track record became a less important factor than willingness to invest time and imagination on the project. The ability to work with many different kinds of people also was paramount.

The crew worked long hours under difficult circumstances and kept working long after the romanticism of international filmmaking was rubbed off by too many airports, boxes of gear, customs officials, missed meals and too few good nights of sleep and days off.

In what follows, the two cinematographers write about some of their reflections, recollections and techniques attendant to the filming of COSMOS:

SEVEN DIRECTORS, NO WAITING
By H.J. BROWN
Cinematographer

This series offered me more in terms of photographic challenges than any single show I had ever done. COSMOS was a one year commitment, with all the forms a documentary series can have, and then some. We did dramatic historical reenactments with a feature look, free-form documentary footage of uncontrolled situations; 35mm live-action special effects; and seemingly simple Carl-to-camera presentations; Mexico, Greece, Holland, Italy for my crew and all the U.S. locations (Chris O'Dell from the U.K. did the other six foreign countries), plus some studio and the COSMOS "black box" where we did "homegrown" special effects.

COSMOS was so large and complex in content that seven directors worked on it. Most of the directorial duties of COSMOS were assigned by individual sequences, not by episode. Given any seven different directors, you're going to get seven different approaches to a given problem. Fortunately not all seven were on the same location at the same time. However, the influences were still present, making it difficult at times to keep all of the inputs separate. Some locations were so massive in terms of material to be covered that two directors were assigned. One would direct in the morning, the other in the afternoon. This would go on for days at a time, sometimes weeks. It got real interesting . . . I tried to combine the best approach of each to make one cohesive piece of film—though I sometimes threw them all out and went on pure instinct.

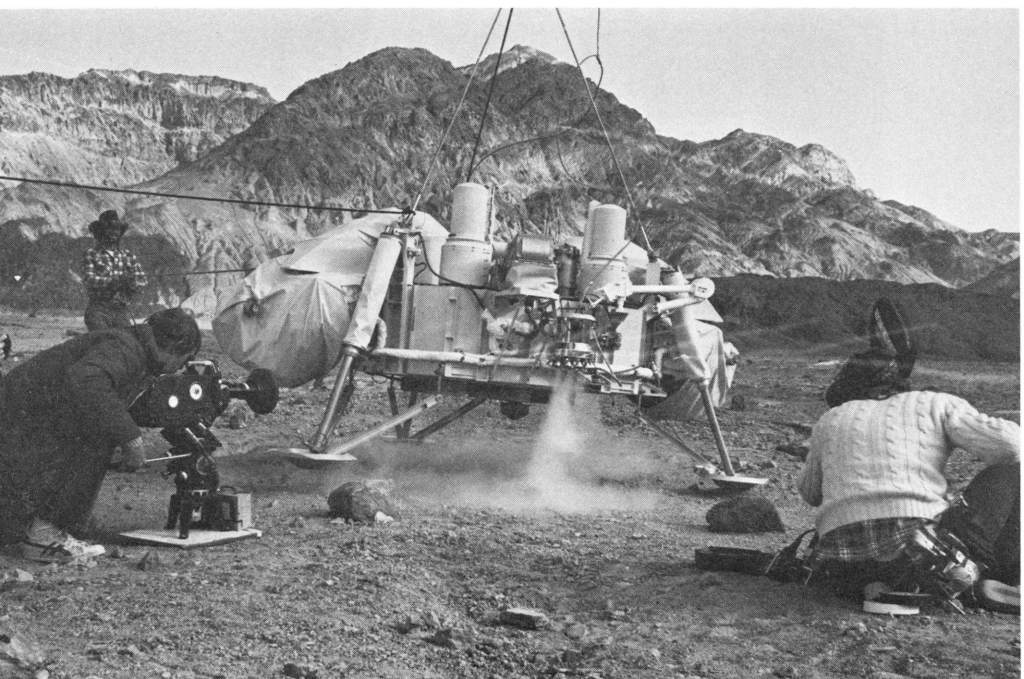
Prep time often involved keeping track of four or five stylistically different shoots at once to fit in with the "critical path, scheduling" of production staff and talent, and two film crews often simultaneously shooting the field. This scheduling was constantly being fine-tuned, as was the content of particular sequences. This meant changes. Directors' responsibilities for sequences, dates, locations, equipment and crew availability, and the content of entire sequences—all changed at one time or another.

There were a great number of historical sequences, each period demanding its own look. In Holland it was 17th century, with candle-lit soirees and seafaring men. Adrian Malone wanted it to be lit à la Vermeer. In Boston it was early twentieth century with young Robert Goddard experimenting with rockets. At Mt. Wilson it was the 1950's. For a UFO encounter it was late night and eerie with a special effects storm adding atmosphere. The look of each sequence was controlled with a combination of fogs, low cons, nets and gells. The directors' intentions were discussed early on in the preparation of each scene, but the final filter and light combination were selected at the time of shooting, after again consulting with the director about physical limitations of that location on that day. Some sequences were shot entirely with an 8mm lens with no diffusion or filtration. Others were done with the longer end of a 10-150 with lots of filtration.

For example, in Holland we rigged a Sun-Gun battery to a 100-watt peanut bulb inside a 16th century lantern. The actors then carried it through the rainy night. In the Holland interiors we put up wall spreaders and hung 15 inkie lamps with lots of ½ and full MT gel. The practicals on the floor were all candles. I also built a set of lens nets which were used on many of the period pieces in different combinations with low cons and fog filters.

For the sequence on young Champollion the windows were all lined with brown tissue paper and six nine-lights were

The Viking Lander, suspended from a crane, is held in place as carbon dioxide gushes out, simulating landing on Mars (actually Death Valley, selected by the American camera crew for its Mars-like landscape). Transporting the Viking Lander to Death Valley was an enormous task, but vital to the realism of the sequence.



placed outside. We wanted to be able to see three corners of the room in one shot, so the only interior lights were two 1K's bounced off the ceiling. I still wasn't getting the right color so I added a gell out of the Rosco sample book to the back of the lens which seemed to give it the right color and softness.

When it came time to shoot at Mt. Wilson we had to shoot the sequence during the day, since the observatory was in operation at night. The inside of the dome is huge and there was no way to light it on our budget, so I decided to open the "window" and let some of the north light in. I set my exposure about two stops under and controlled it by opening and closing the window. The two main characters were then lit with tungsten 1K's and the daylight was left as a cold night blue. To add another element to the visual approach to this sequence, it was all done with the Zeiss 8mm lens. It was the use of this lens which allowed us to show the scale of the observatory and still remain intimate with the actors.

In the re-enactment of the UFO encounter we find Betty and Barney Hill driving through the rain at night on a deserted road to find an alien space ship in the middle of the road with the aliens approaching. Among the special effects used were rain machines, fog machines and lighting machines. The entire sequence was shot exterior in one night. The alien craft was created with heavy fog machines in front of 1K and 2K lights, while the rain and lightning thunder on. The closeups of the actors driving were done with the car stopped, a tent over the camera, rain on the windows, 2K's passed over the top of the car, and nets and flags choreographed in front of lights on stands, to give the effect of street lamps and passing vehicles.

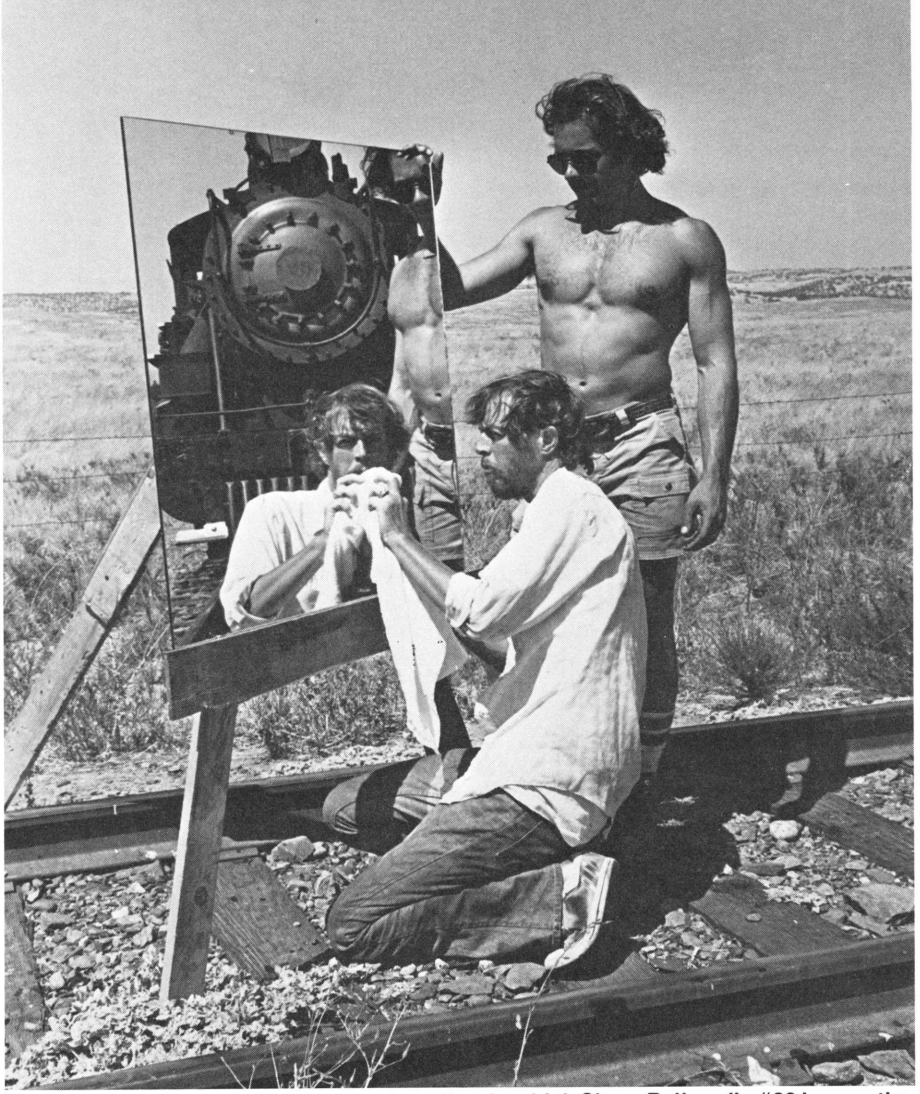
For several of the historical reenactments we used glass paintings to add elements to the scene that didn't exist, or to hide structures of the wrong period. We used two in Holland, where it was so cold and rainy that we shot from the inside of a five ton grip truck, and kept the lights on all day to keep the painters' hands and the paint from freezing. Ships were painted and smaller boats, under walkie-talkie control, sailed amongst them. Later we turned an L.A. golf course into medieval England, adding a complete Gothic cathedral and surrounding hills and trees, and again combined this with live action, this time with hooded monks. The glass shots are hard to spot if you don't know they're there. I once called the folks at home base to check on the glass shots; they couldn't tell they'd seen them and said "What glass shots?" I just said thank you.

Special effects are a large part of COSMOS and not all were done with hi-tech animation. We did some of it "live action"—scale models, locations with Carl, water tanks, falling rock and some pyrotechnics. Model shots were done on stage with the Kenworthy Snorkel System on a Chapman crane. Atop the snorkel was a high-speed Mitchell. Each model was about 10′ X 10′ plus a backing about 15′. Some backings were gorgeous paintings, some star fields of black seamless with holes, and some were just white backings with gelled lights. To each of these planet models was added smoke and fog to effect dust storms and atmosphere. In order to match the scale and speed of these effects the high-speed Mitchell was cranked up to 125 fps. These effects then became process plates, being projected into the "spaceship of the imagination".

Practically, the Kenworthy Snorkel starts with a wide-open T-stop of 8 or 9. Add to this a 125 fps frame rate (or two stops) and an additional 1½ stops for the pola screen to cut the sheen off some of the models and you have a wide open T-stop of 22-32. We pushed the film a stop and lit the models with about eight 10K's. Hot . . .

To add to the atmospheric density and reduce detail in the models we used nose grease on the snorkel's mirror. To make the space ship fly in and out of clouds we would first breathe heavily on the mirror and start the shot as it cleared. Director Adrian Malone had the best technique for breathing and running to look at the monitor, so he was hired. Following focus on a black and white monitor through a lens system covered with nose grease, shooting at a fogged set with a visibility of eight on a ten-foot model with a moving snorkel—my assistant, Corky Quakenbush, discovered Zen, I think. And my gaffer, Scott Spencer, never stopped trying to get it right no matter how screwy the lighting scheme looked. Anything to get it on the screen.

I also did a whole collection of other effects, some special and some not so special. We made stars fall out of a dusk sky and onto a beach with Carl walking and talking in a bed of stars. This was done with a pyrotechnic fountain and 1,000 Christmas lights in the sand. Clouds and lightning were done in a seventy gallon water tank with milk, cold



Setting up diagonal mirror for a shocking effect in which Sierra Railroad's #28 locomotive will appear to crash directly into the camera lens. Actually, the camera will be safely off to the side, while only the mirror will be smashed by the impact of the onrushing train. An old effect, but still impressive to audiences.

water and flash bulbs. We flew through the rings of Saturn with 400 pounds of crushed rock, and glass slag using three manlifts and a thirty foot square sand box, a set of four dump tanks and a strange metal chute—all at 500 fps looking straight down.

To tie all of these different sequences and styles together Carl Sagan, throughout the series, would be mostly delivering dialogue to camera. Due to the length, scientific accuracy, and complexity of Carl's camera dialogue, cue cards were used throughout much of the production. Cue cards at ten feet are slightly limiting when you've got a case full of lenses and you've travelled thousands of miles to some great locations.

As a result, a rather elaborate scheme of cue card placement was used to achieve maximum value from the location and allow Carl a smooth delivery. We put cue cards of every size and shape in, under and around everything. People walked along holding them on dolly shots and 300mm lens shots. We put them in books and tacked them to trees and placed them in the grass. We also did a lot of shots where he was too far away to see sync and the correct words were laid in later. In this way we were able to get much more out of each location and design some shots that weren't just head and shoulders.

Many of the sequences we did didn't demand any special effects, but were still very challenging. One particular location was the New York City Public Library. We needed to photograph Carl walking through it observing the massive library yet be totally unnoticed ourselves. We also needed to steal shots of the public deep in concentration. The answer was to build a briefcase with the NPR inside. It was shot with fast lenses. The box was made of plywood with a hole for the lens and one for the orientable eye piece. It was then covered with black vinyl and a handle was added along with an on-off switch. It worked better than I had ever imagined.

The Lowell Observatory in Flagstaff, Arizona, is a beautiful wood structure, whose interior dome is natural wood with a gloss varnish finish. The tricky thing about observatories is that the dome rotates and any lights that you hang on the dome also rotate. A lot of careful planning of the sequence and blocking of shots was done before any lights were hung.

We found a perfect old Forties diner in Brooklyn for another sequence with Carl. The only problem with the diner was that it was lit with flourescent light and that kind of look was all wrong. I went out and around the corner found a hardware store and bought some hanging aluminum lamp shades, wire and plugs. The diner was an aged Chinese red color, so I used spray paint with some brown streaks and tips to age the newly purchased shades, then screwed in some 211 globes, and hung the whole works from the flourescent fixture which is out of frame and shot.

The shooting at the Jet Propulsion Laboratory in Pasadena was done during the close encounter with Jupiter by Voyager. This was the only truly documentary shooting on COSMOS. We slept in motor homes in the parking lot for three days on 24-hour call. The interesting thing about this was that we were allowed into areas in JPL where no news crew has ever been during a close encounter. We shot with Zeiss fast lenses and let the lab correct for the flourescents.

There is a sequence in COSMOS which used both a 3.5mm Century Precision lens and a 300mm lens. It is what we called Doppler Train. We got an old train up near Sacramento and rented a 100' crane and basket. We shot from the basket suspended over the train at varying heights with the 3.5mm and buried cameras under the train as it passed over. Then we moved down the tracks a long way with the 300mm to shoot an old prospector crossing the tracks with a mule. The two lenses in combination are quite striking.

When we arrived in Greece we had only camera, lenses, two Sun-Guns, and some reflectors. We were shooting on the island of Samos, a gorgeous vacation island not very conducive to work. When we arrived we couldn't shoot because of a little problem between the armies of Greece and Turkey, so we scouted the island and took a much-needed day off after five weeks on the road. About 20 kerosene lanterns were used to light the caves in Greece with Sun-Guns used to light Carl. At one point we wanted to dolly with Carl along a wharf and the only way to accomplish this was in a rowboat with a hundred feet of line attached to each end. We were then pulled gently through the water. The only other time we used a dolly in Greece was in a little town square where a wheelbarrow was put to use.

The bulk of the 168,000 feet of film I exposed on COSMOS was put through a

(ABOVE LEFT) An interesting lighting effect recreates the proper atmosphere for a 1920s sequence. BELOW LEFT) Cinematographer Chris O'Dell lights a medieval feast in Czechoslovakia for the Johannes Kepler sequence in Episode 3 of COSMOS. (RIGHT) Subjective camera angles helped to personalize points of view in recreating episodes from the life of Kepler. No detail was spared in the staging and photography of historical sequences in order to make them as credible as possible.

(LEFT) A high crane shot of the train on location in Jamestown, California was used to illustrate the "Doppler Effect". Animation of the sound waves spreading out was later added to the shot. (RIGHT) The moment of impact, simulating the Tunguska Event when, in 1908, a giant fireball devastated a remote area of Russia—here recreated in the Angeles National Forest. (BELOW RIGHT) Village children dance around the maypole in 1979, just as in 1894.

seven-year-old Eclair NPR with three mags and a Perfectone motor. The camera must be an effortless tool, one which serves to record, an extension of one's own body. It is one of the only tools in this business that will put you completely out of business if it fails. Mechanical, optical or power failure and you're in trouble. I keep a schedule of footage through both my NPR and ACL II. In this way there is a complete history of what was shot, where and when, as well as a complete service record. A regular servicing to just clean, lube and adjust is the cheapest insurance policy one can have against mechanical breakdown. Equipment reliability is the last thing you want to worry about on location, especially when you are half-way around the world in adverse conditions. My Eclairs afford me a tremendous luxury—peace of mind.

Above all I enjoyed most the abstracting of reality to create a new reality, a film reality. Visualizing a situation and an environment and capsulizing it into a film experience. Each day would bring a world of varying situations, interpretations, and problems to solve photographically. We built from concept to visual reality an original piece which will educate, enlighten and entertain.

To say shooting COSMOS was a challenge and a chance to grow is quite an understatement. ■

LOCATION SHOOTING FOR KCET'S "COSMOS"—INDIA, EGYPT, GERMANY, AUSTRIA, CZECHOSLOVAKIA, AND ENGLAND

By CHRIS O'DELL

Lighting Cameraman.

In the autumn of 1978 Andrew Lee, Managing Director of Platypus Films, and myself, were contacted by David Kennard to offer us the possibility of working on the KCET project COSMOS. Naturally we were delighted to be considered for this major production. As the largest film servicing company in London, Platypus had handled many difficult foreign locations, and I had shot a fair number of historical reconstruction films and documentaries. We knew we could provide the crew and equipment necessary, as well as the production back-up from our base in London's Covent Garden area. We were thrilled when Kennard telephoned us from Los Angeles to say we had the job.

Several weeks passed whilst discussions took place about equipment, logistics, and the complex schedule prepared by KCET to maximize the use of presenter Carl Sagan's time. At the end of this period each member of the crew was presented with an immaculately bound schedule containing every bit of information he would possibly need. This gave us a lot of confidence in KCET's production department; evidence of a really professional approach like this gets everybody off to a good start.

We were also presented with a clapper-board to be used on the production. In Britain it is not customary to put more than very basic information on the slate: the name of the production, the director's name, the cameraman and the slate and take number. The American clapper-board presented us with a bewildering amount of information to fill in, including a mysterious metal clip saying "MOS". Fortunately we managed to lose that on the first day, but my assistant spent a lot of the next few months writing!

INDIA

On January 9th, 1979 the party—consisting of myself as lighting cameraman, assistant Peter Rees, sound recordist John Page, and electrician Len Emery—met producer David Kennard at London's Heathrow Airport for the flight to Bombay. The equipment made an enormous pyramid beside us as we

checked the *Carnets* through customs. Although I had taken delivery of a new Aäton camera nearly six months previously, and had already run many thousands of feet through it, this would be its first really punishing trip far away from base. I carried a full set of high-speed Zeiss Distagon lenses, including 9.5mm to 25mm, 5.7mm Kinoptic, 8mm Zeiss Distagon, 10:100mm Zeiss T-Star Zoom and two longer Nikkor lenses with adaptors, a 200mm and a 300mm. A full set of combination filters, pola-screen, Harrison low contrasts, and nets were carried, as I expected to have the opportunity to produce some in-camera effects on some of the dramatic reconstructions.

I chose the Ronford Fluid 15 head and

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THE SPECIAL VISUAL EFFECTS OF "COSMOS"

By GREG ANDORFER
Producer

Achieving the "out-of-this-world" illusions necessary to the series required the use of nearly every available special effects technique

"The reality of the cosmos exceeds our ability to imagine– truth is stranger than fiction!"

This is what we were striving for. Real space. Scientifically accurate. We knew that if we were dedicated to this that we would achieve something important, particularly for a series that, from the beginning, wanted to educate, but also to inspire and to entertain. To achieve these lofty goals we knew we had to depart from the more traditional scientific program ways of conveying information. Part of this was in the script, in narrator Carl Sagan's ability to turn a scientific phrase, giving it an almost jewel-like quality, sometimes becoming nearly a metaphysical conceit, and in so doing, making the concept instantaneously comprehensible to non-scientific ears. The other part was to give the audience an experience of this scientific reality. To take them to exotic places. Real places they had never seen before.

We would do this primarily via the Cosmic Zoom—a ten-billion-light-year journey from somewhere near the "edge" of the universe through clusters and clusters of galaxies, on to our local group of some twenty galaxies, then on into the Milky Way Galaxy, visiting a variety of interstellar phenomena, other planetary systems, and eventually into our solar system, past its variegated worlds, skirting the surface of a familiar planet, and then on home to Earth.

We didn't know what kinds of problems we were going to get into. Neither did we have any idea that producing more than eighty special and visual effects sequences for this thirteen-hour series (the effects alone comprising some two-and-a-half-hours of screen time) would present so many difficulties and yet so many challenges. As a laboratory of effects production there certainly has not been a television series, perhaps few feature films, that have presented such a wide range of experiences.

The story of COSMOS's visual effects began with a funny list of techniques (a dream list) during our research and development period. As we began to clarify series ideas we knew we wanted this production to be visually special. So we promised a list of effects to our fundors that included nearly every available special effects technique, both current and past. We had only a vague idea when this list was first put together just how we would use every one of these techniques, but we had a strong feeling that we somehow needed to use all of them.

From this early exhaustive list of techniques (you can imagine your own) I think we used every one except perhaps thermography, an obscure form of filming where heat and not light exposes the film. We used, for example, state-of-the-art three-dimensional computer animation to model the master molecule that powers all of life, DNA (with five computers necessary to compute the thousands of frames); liquid tank work with rotoscoped lightning flashes to create the dense clouds of Venus; snorkel camera systems to fly across model planet surfaces, down deep canyons, through dust storms; motion repeating systems and multi-plane artwork to build dimensional nebulae that we could fly through; blue screen process for mixing planets and moons and starfield backgrounds; travelling mattes so we could put one part of a scene inside another, creating the world inside a white blood cell; dual unit video matting systems (Magicam) to recreate the ancient Library of Alexandria, or the inside of the brain for our host to walk through (see Magicam article); some classical hand animation work on standard animation stands; even, to use Executive Producer Adrian Malone's words, some "string and sealing wax" for homegrown effects.

Our initial treatments had grand descriptions of illusion we hoped to achieve through elaborate effects. Breaking these early descriptions into manageable techniques was an enormous team and organizational effort. Susan Racho, particularly, as Special Effects Coordinator did an enormous job of tracking all of the individual sequences.

After we had generally outlined these effects sequences in a month-long production meeting led by Adrian Malone, Jon Lomberg, an artist from Toronto, joined us as we began to think about the finer details of discrete design and production of each effects sequence. Jon had done some illustrations for Carl Sagan's books, was part of the selection team that put together a music and picture message, attached as a long playing record onto the *Voyager* spacecraft, and had written scientific programs for the CBC radio. He had a tremendous grasp of science and brought many new conceptual approaches to the series.

Our first design task was to establish a "look" to our space effects. Jon, and later Rick Sternbach, mostly labored over "Key Frames", small paintings with more precision than our detailed sequence storyboards that were to come later. At this point science formed the backbone of pre-production designs.

Take the Milky Way, our own spiral Galaxy. In the Cosmic Zoom, part of our trajectory takes us from outside the Milky Way into a spiral arm and then we settle down for our trip home to Earth.

If you look at the Milky Way from Earth it is a diffuse white background band comprised of billions of distant stars, with a healthy dose of obscuring dust, that we see edge-on, as if we were seeing the edge of some massive plate. How then do you accurately show the galaxy from above, face on, when we don't have any such vantage point? Certainly we looked at pictures of other spiral galaxies. But then, with the help of numerous scientific consultants, particularly Don Goldsmith and Steven Soter, we consulted radio telescope and other electromagnetic spectrum mapping data about the size and shape of the galaxy, of the relative placement of its core and spiral arms, this gave us a "composite" rendering of something we don't have enough information about purely from the visible spectrum. This is but one small example of our detailed production design effort. Maybe not all of our science checking is evident on the screen, but the gradual and cumulative effect does make a difference.

THE SEARCH FOR TECHNIQUE

There were numerous ways our visual effects could have been done. Some were readily obvious because of the effect we wanted, but for our "space" effects we had many different proposals from effects houses around Los Angeles. We were certain, however, that the final look and the production technique were inseparable if we were to insure scientific accuracy. Otherwise we were leaving too much to chance. We didn't want to see our often painstaking research get lost in near accurate techniques. We had to have a lot of control throughout the production phase of our effects. A lot more than is generally needed, even from the most demanding directors. One well known special effects wizard, after looking over our massive notebooks of storyboards (300 just for the Cosmic Zoom) and discussing a few specific shots, guardedly said, "Sure I can throw some chemicals into a tank, shoot at high speed and you can have a beautiful

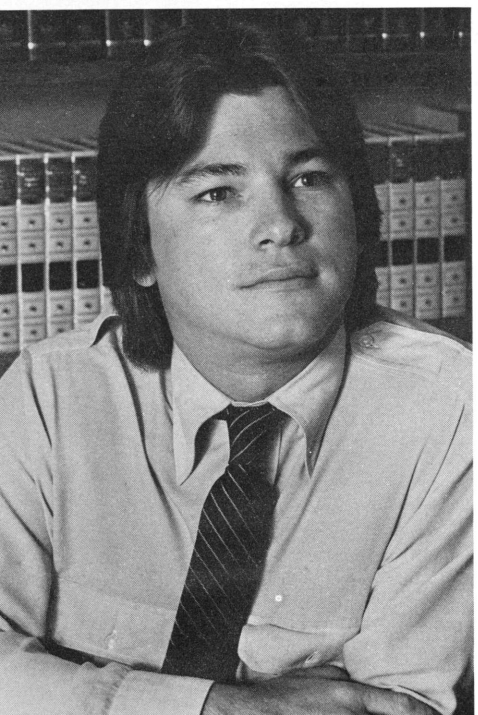
nebulae, but when it has to be the Crab Nebula, with specific shape and specific color then it becomes really difficult . . . this science accuracy thing scares me."

Degree of control over the look thus became an even larger concern as we talked to nearly every special effects group in town—a useful education in itself. We began to get a variety of imaginative approaches. Some presentations were quite detailed, suggesting how each shot might be executed, others suggested an overall technique and left the impression that they'd solve each shot problem as it arose.

There were large cost differences. Cost quickly became a primary concern, along with artistic control. It also became clear to us that a production facility with optical compositing capabilities was useful, if not essential if we were to finish our numerous effects in time for their integration into the spaceship, and for staff, logistic and budget reasons.

Because we had so many shots (once calculated to be more individual elements than the first STAR WARS feature), shooting all the elements and then trying to find someone else to assemble them was out of the question, timewise and costwise. By the time we were bidding our effects, the industry was going through a change, which also had a significant impact on our budget that had been put together nearly a year earlier. A second generation of effects makers were starting their own businesses. Most of the first generation of new wave effects artists were tied up on features, though their response was interesting and encouraging. But we needed full-time attention. We were put into a bit of a gambling situation. We were hoping to get lucky. Sometimes we were, sometimes not.

Visual Effects Producer Greg Andorfer estimates that the more than 80 effects required comprised some two-and-a-half hours of screen time.



Where we were lucky, and what helped us hedge our bet, was a group of people who became known as the COSMOS Artists, each later distinguishing himself in a variety of ways in executing COSMOS's visual effects.

The COSMOS Artists are a unique group of artists. Artists who are individually dedicated to painting accurate spacescapes and celestial and cosmic objects. They paint some fantastical fictional pieces, but mostly they seem to be driven and inspired by the excitement of reality and science. They are a new breed. As designers and artists, theirs is an emerging style based on scientific accuracy.

Galaxies are a basic blue because you mostly see the hot young blue stars, which burn brighter and outnumber even the billions of red, yellow and white stars in a typical galaxy. Nebula colors are gleaned from a variety of data, not just from optical telescope pictures where the simple choice of photographic film for the telescope can forever limit our idea of what the multi-colored nebulosities really look like. So what they render is frequently more accurate than familiar observatory photos.

This group was essentially new to any filmmaking. They are, however, the best space and astronomical artists working. They include: Don Davis, who worked for the U.S. Geological Survey, painting landscapes. Don worked mostly on extraterrestrial landscapes, for us, using spacecraft data to make detailed models. He, in fact, supervised most of the actual model building. Adolf Schaller, from Chicago, is undeniably a master of the airbrush, has an incredible imagination (see cover of this issue), and painted some very fantastic and intriguing pieces for the series, and like Jon Lomberg, was a science consultant for the effects, as well. John Allison, from Toronto, whose speciality is brightly colored gaseous nebulaes, in a production crisis became a team leader, planned and shot many of the effects, seeing many through to completion, later learned optical lineup, and then supervised the assembly of our numerous and incredibly detailed shot elements. Adolf Schaller frequently joined him in supervising many of the effects. (Interestingly John also generated many of the original sound effects for the programs.) Rick Sternbach, who had steadfastly worked with us during the design phase, has painted many science-fiction book covers, but for us painted beautiful planets and was perhaps our most all-around artist, shifting gears quickly from one design task to another. Brown, from Toronto, contributed many design sketches and did many of the drawings for our computer animation sequences and detailed planetary surface models with plaster, wax, and other messy materials. Anne and Ernie Norcia, from Ohio, also contributed to the accuracy of our space effects. Of course, Jon Lomberg's initial designs and some of his artwork remain among the best pieces of the series.

HOPEFULLY A SOLUTION

After scouring Hollywood for the right effects house to meet all of our needs and one that we felt comfortable with, we selected Motion Pictures, Incorporated (MPI). A test phase to determine the look of the effects, as painted by our artists, was quite successful. We all began the production with great enthusiasm. Central to the chosen technique was a multi-plane artwork technique.

Each object, such as a galaxy, a nebula, or a globular cluster, was to be the composite image of the shooting of many separate acetate cells, each single piece contributing to the full-dimensional image. We had also hoped to get a multi-axis technique that would have given us even greater diversity in shot execution and look, but unfortunate systems engineering in the making of the equipment for this technique prevented this from happening.

Our effects techniques were involved: stop-motion photography for the slow rotation of a galaxy; single-frame front light and then backlight of planets or models to create both the image and hold out matte. After shooting of a starfield background, and optically separating the positive and negative image of the planet to make two registered pieces, the separate elements were assembled on an optical printer. This technique was only moderately successful.

Some multiplane animation stand work was also done when the shot only required short and simple trucks and the object we approached did not have to grow from a point. Some table top models were built and shot, though we reshot most of them later at KCET.

When the shot called for an object to grow from a distant point and move to full screen, such as in the Orion Nebula sequence, a long forty-foot track was used. Artwork was placed at the far end and the camera had the capability to truck the length of the track. An instrumentation tape deck was programmable in three modes to build the shot. Many long nights were spent along side this device, dubbed "THE CAMEL".

Programming and shooting often took days per shot. The COSMOS artists, particularly John Allison and Adolf Schaller, rallied by Adrian Malone, learned to set

up each shot, determining the camera truck speed down the track towards the artwork, the camera frame rate (usually 6 frames per second), and camera fade for each piece of artwork shot. Staggering of the individual acetate cells helped create a sense of depth. Some sequences had over eighty separate passes of runs of the Camel, as with the Quasar shot, that is also used for the series title. Usually a single negative clip was constantly re-exposed. Fortunately light from space is mostly additive. Can you imagine 80 hold-out mattes!

Sometimes science and reality were good to us. Our approach to the Orion Nebula and our flight through to its interior involved a composite or mix of some eight picture elements and hold-outs shot on both the long track, and an animation stand, fiber optics for the hot stars just forming in the center of the nebula, were also shot on the long track. What seems a smooth shot when you watch the effect is actually made up of many separate elements. Special thanks are given, in fact, to those who carefully looked after all of these separate elements, particularly Bea Dennis, our Post Production Film Manager, who also edited many of the effects, Susan Racho of COSMOS; and Nancy Rushlow of MPI. The production management of sophisticated visual effects requires exhaustive attention to detail.

Because of the impending schedule of the spaceship studio shoot, for which most of our effects were to be integrated (see Spaceship article) and because of some disagreement about the quality of effects, we decided to shoot many of the table-top models at KCET. Director Adrian Malone suggested new shots. New plans were drawn up. Models were redone, enlarged, new backdrops were painted, more cohesion was introduced into each shot for stylistic continuity among shots and the effects were generally "beefed up" for more drama. The science got better, too.

Most of these planet surfaces were shot using the Kenworthy Snorkel Camera System. With dust storm-like effects added, believable scale was constantly a problem, but cinematographer H.J. Brown and crew solved these and their shots remain some of our most convincing.

The story of our descent to the hell-like surface of Venus suggests how, at the same time we were solving technical problems, we had to keep accurate lock-

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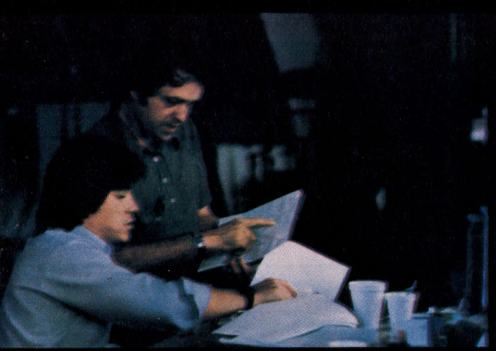
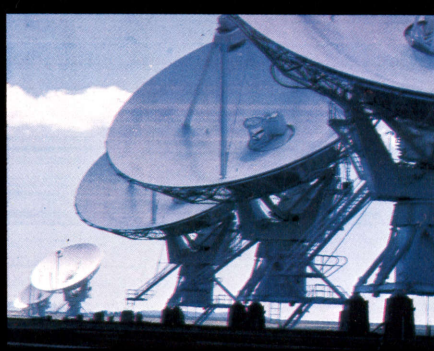
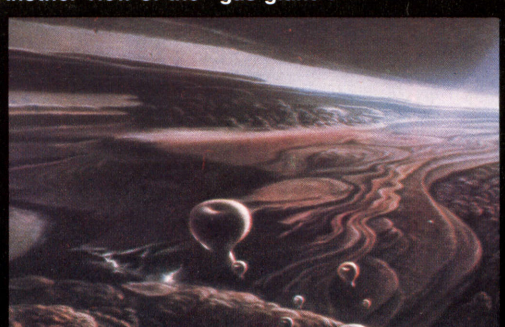




(LEFT) Visual Effects Producer Greg Andorfer discusses script point with scientist and series co-writer, Dr. Steven Soter. (CENTER) The objective was to produce effects that looked like they had been shot on location—such as this incredible picture of Jupiter from the Voyager spacecraft. (RIGHT) Many of the visual effects were modelled on data outside the visible spectrum, obtained from radio telescopes. Here is the Very Large Array (VLA) in New Mexico.

(LEFT) Masters of the airbrush, artists Adolph Schaller (left) and Don Davis, painted many models and backdrops. Remarked Don of a floating Schaller cloud: "That's the most beautiful cloud I've ever seen." (CENTER) Producer Greg Andorfer looks on as Chief Artist Jon Lomberg puts some finishing touches on a volcano for the Titan moon surface tabletop model. (RIGHT) "The Last Good Day", first of a painting sequence by Adolph Schaller depicting the fate of our sun. It will become a red giant star, growing to destroy the Earth—some five billion years from now.

(LEFT) Saturn looms in the Titan sky. This moon may have an environment capable of supporting life. Background by Adolph Schaller and Don Davis. Foreground model by the COSMOS Artists. (CENTER) Artist Schaller's speculations on life on a Jovian, or "gas giant", planet. These "Floaters, Hunters and Sinkers", some of them kilometer-size living air balloons, might evolve in the massive convective currents of this imaginary planet's atmosphere. (RIGHT) Another view of the "gas giant".



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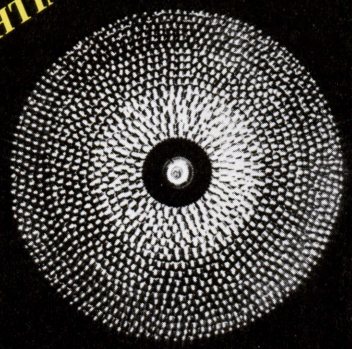

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ON LOCATION FOR "COSMOS"

Ranging over 40 locations, many of them in foreign countries, the COSMOS camera crews spared no effort to film very special footage

COSMOS—THE LOCATIONS
By DAVID KENNARD

Almost two thirds of the thirteen-hours of COSMOS was filmed on 16mm film on location. We faced three major problems:

(1) How to compete with the super-sharp quality of the video and 35mm special effects.

(b) How to integrate location film stylistically with video scenes and space effects.

(c) How to manage and organize location filming in three continents over a period of 18 months.

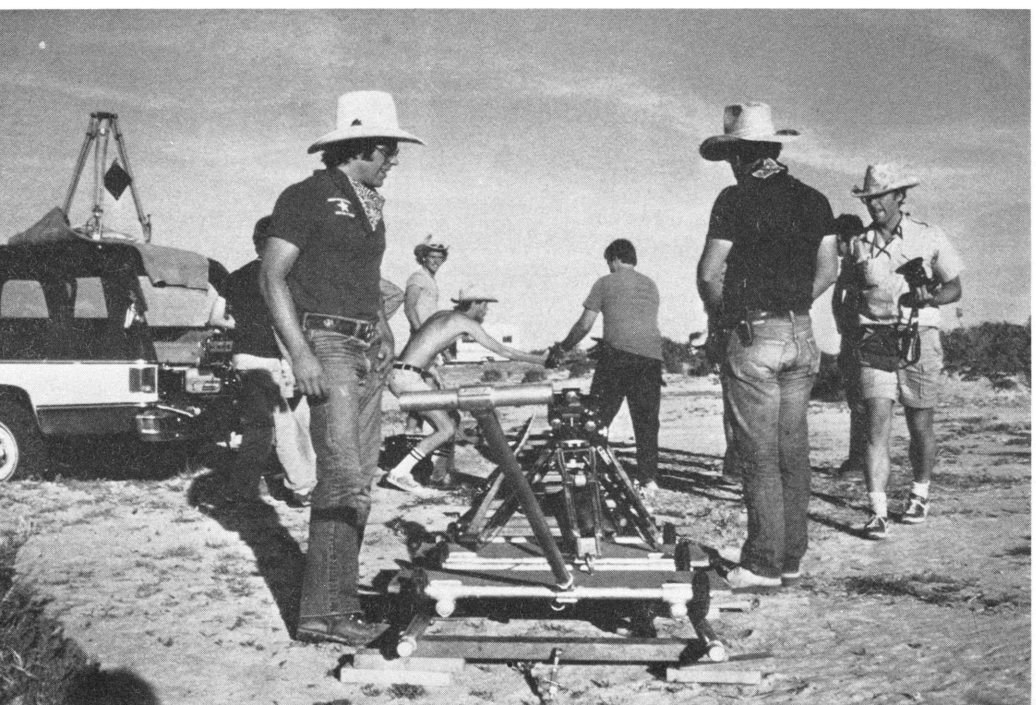
There's no easy solution to the first problem. In spite of heroic efforts at the laboratories (CFI, Hollywood) over a period of more than six months, you can still see a few joins where video or 35mm film sit back-to-back with 16mm. The trick in constructing the programs was to create bridges between the sequences which obscure the subtle changes in texture and quality. At the same time behind the camera, Chris O'Dell and H.J. Brown and their associates sweated blood to achieve pin-sharp focus and a clean camera gate (see the article on Cinematography). Beyond that, there was nothing much to do: even with a more than $6 million line budget, you cannot afford to take 35mm equipment three times round the world, over a period of a year and a half. Faced with a major quality change at the final video editing stage, we planned a music crescendo that would take the mind off the picture!

Stylistically, we all wanted COSMOS to be as rich as possible. Somehow, we knew we had to devise a format which would show the diversity of human life and experience, in many cultures, across a time-span of 1000 years. So, we would develop scripts which allowed us to mix period costume drama with science fiction, video spaceship effects with documentary footage, exotic location work with scanning electron micrographs. For the directors, myself included, it presented an opportunity to direct in every possible style we could imagine. For the producers, it presented the challenge of ensuring that we could weld these disparate pieces together into a satisfying mosaic.

In terms of management and organization, COSMOS provided an acute and sizeable headache. With experience as producer/director on *Connections* and *The Ascent of Man,* among other series, these were not new problems. However, this was the first time that the originating station, KCET-TV of Los Angeles, had filmed any substantial sequence outside of the state of California; now, we were spending months in Japan, India, Holland, Mexico . . . Add to that the fact that we often had two crews on the road at once, with Carl Sagan shuttling between them. The insert articles by Janelle Balnicke and Cameron Beck give a flavor of two aspects of the Production Assistant's job on COSMOS: one describes the intimate relationship that a film team can develop with a location; the other is a simple saga of keeping the show on the road.

All in all, COSMOS probably contains as wide a spectrum of television and film techniques as you will find in any single series. Even within the location work, it is hard to think of a film *genre* which is not—somewhere—represented. ■

Producer David Kennard (at right), Associate Producer David Oyster and Production Coordinator Cameron Beck (far left) discuss a tracking shot being set up on the "Campfires and Constellations" set outside Chaco Canyon National Monument, New Mexico.



LOCATION AND SPECIAL PHOTOGRAPHIC EFFECTS
by DAVID OYSTER

"There are more stars in the cosmos than there are grains of sand on all of the beaches of the planet earth." "To ride on a beam of light." "In 1908 a piece of a comet hit the earth."

These mind boggling concepts, among others, along with Executive Producer Adrian Malone's exhortation to "invest in imagination" led to the production of some of the most interesting location and special photography effects in the COSMOS series. While COSMOS was generously budgeted, it was not astronomically budgeted and necessity was once again on the way to the delivery room.

A discussion of the size of the universe and the number of objects it contains is an ambitious task for even the most sophisticated scientific and philosophical minds. It was our job, as non-scientists, on COSMOS to gain a basic understanding of the science and translate that into a stimulating series of television programs which would both inform and entertain, and still maintain scientific accuracy. This led to a lot of interaction and sometimes highly animated discussion amongst the producers and directors and the scientific advisors. The result, however, is stimulating aurally and visually, as well as intellectually.

To illustrate the stars and sand analogy we chose a beautiful section of the Southern California coast. The idea was to have Carl walking on the beach at sunset discussing the size and scope of the cosmos, at one point he was to reach down and pick up a handful of sand, which he would then toss into the air, and that handful of sand would in turn magically change into the stars of the twilight sky. From this starry sky the remainder of the episode would unfold, until at the end the stars would re-animate and fall to the ground littering the beach with twinkling lights. This sounds simple enough until you start to underline a few of the key words. For example: sync-sound, beach, sunset, twilight, falling stars, lights in the sand.

The most important element in making

a scene like this work is preparation. The second most important element is luck, because there are many uncontrollable factors. One needs to know that at high tide the location is partially under water, and then to check the tide tables and find a day when low tide and sunset coincide. Then you must check the direction of the prevailing wind and attempt to block the shots so that you have a fighting chance of getting tracks that are not all but obliterated by wind and surf noise. Once the preparation is done and you realize how long it is going to take to shoot this little scene you hope and pray that you have two pretty identical sunsets in a row.

To effect the conversion of a handful of sand into stars in the night sky required a combination of shots and laboratory opticals. On the location we had Carl throw the sand into the air and photographed this in a tight shot at normal speed and at 400 fps using the Action Master Camera. By dissolving between these shots as the sand scattered we were able to begin the transformation. The location shots were combined with some shots we had done in our basement insert stage and $1.98 special effects tank lovingly known as the "black hole". These shots consisted of combinations of silica sand and mica chips lit very hot and photographed against black at 400 fps with the Action Master. We employed a series of slow dissolves and an optical freeze frame to transform the handful of ascending sand, to ascending stars, to a star-filled sky.

The shower of stars at the end of the show was accomplished in a similar manner, but with an added element: pyrotechnics.

To begin the shot was a simple matter of unfreezing the star field and reverse printing the ascension of the stars so that they appeared to fall. To achieve a more realistic effect I wanted to be able to see the stars falling around Carl. For this I called on my old friend Harry Woolman, the "Master Blaster". We tested a few ideas and finally resorted to gerbs, a Fourth of July type fountain. Since the sparkles from the gerbs looked a lot different from the silica sparkles we had to film gerbs against a black background and combine them in a long dissolve with the silica. This gave us a transition between one type of effect and the other. On the location we placed the gerbs high on a ladder between Carl and the camera, again wind direction was important. When we rolled the camera the illusion was that Carl was standing in a shower of stars.

To complete the effect we carefully placed one thousand small Christmas tree bulbs in the sand. This shot had to be precisely lined up as we wanted a very wide shot but could not afford the time or money to light the entire beach. We took advantage of some rock formations and the natural slope of the beach to create the illusion of an infinity of stars stretching to the horizon. By carefully planning the shots we managed to reveal this little surprise at the last minute.

David Oyster and Cameron Beck head up an expedition deep into the outback of Chaco Canyon National Monument to film ancient Anasazi Indian petroglyphes depicting the explosion of a supernova in A.D. 1066. Motor vehicles are not permitted into the remote areas of the national monument.

The entire sequence was filmed at magic hour during the course of two evenings. We arrived at the location early enough in the afternoon to rig the lighting and the effects and to rehearse the scene over and over. We knew that we had, at most, three takes for each set-up. There wasn't much margin for error, everything had to go very precisely. The first evening went very quickly and not entirely as planned, we were very relieved after dailies the next morning, we had what we needed for the first part of the sequence. The second evening went off without a hitch and the light was practically a perfect match. The next morning the dailies were terrific and we felt very good as we walked through the rain to our cars, knowing that we would not have to use our contingency day.

The Tunguska Event

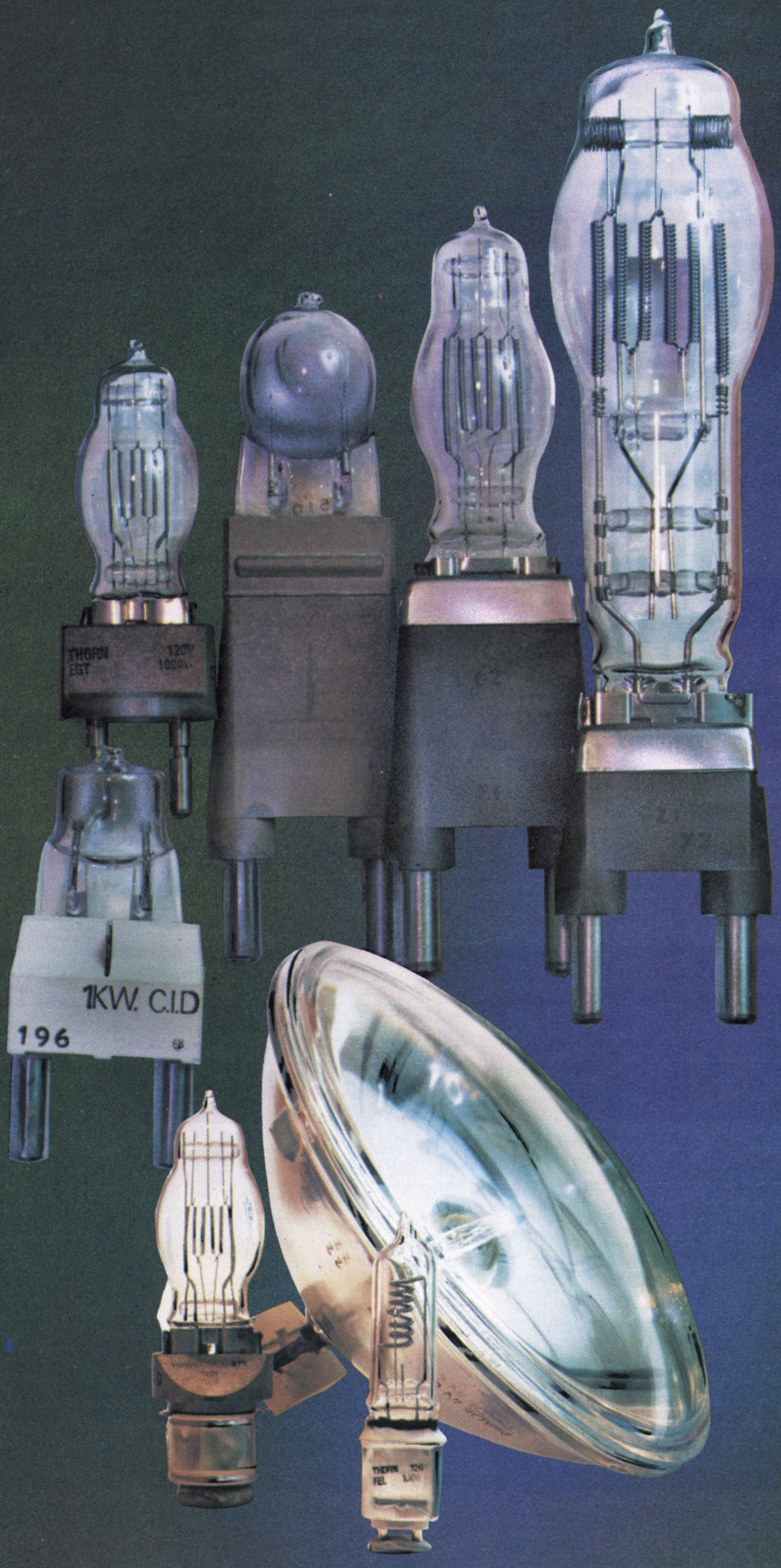
Episode Four of *COSMOS* deals with the catastrophes that can befall a planet over its lifespan. It was somehow fitting that one of our major locations for this episode was an area in the Angeles National Forest which had been ravaged by an intense forest fire. The eerie hulks of the burnt-out trees provided a mysterious and mournful atmosphere for the discussion of planetary disaster.

In 1908 in a remote part of Russia something very mysterious happened. There was a great fire ball, a concussion wave, and vast areas of trees were flattened. An expedition some years later discovered no remnants of an extraterrestrial object and no radioactivity. What happened? It seems that a piece of a comet hit the earth.

To simulate the impact of a comet on the earth we combined animation, matte photography, and live action photography with normal and high-speed cameras. We went to the Angeles Forest and shot some plates of forest and skyline in increasingly closer perspective. These were done with a 35mm Mitchell camera because we needed the registration. These plates were later used as backgrounds for artist John Allison's animation of the comet entering the atmosphere and descending on the forest. The last frame of the animation whites out the screen as the comet fragment airbursts in a ball of fire over the forest. This scene then dissolves to a sequence which was shot with multiple cameras of a tree exploding. By using varying focal lengths and frame speeds we got several different angles out of one tree and it appears that the whole world is on fire.

The special effects were provided by Harry Woolman who did a masterful job of lighting up the tree without getting the cameras or the crew. This was technically not that difficult a shot. The difficulty was more political and personal. It came down to this: We didn't want to destroy a living tree for the sake of our special effect and the Forest Service didn't want us setting any large fires in the forest. Mother Nature intervened. Large areas

Continued on Page 1042



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COMPUTER MAGIC FOR "COSMOS"

By DR. JAMES F. BLINN, PAT COLE and CHARLES E. KOLHASE

Creating "artificial reality" through the use of computer graphics made possible many scenes that could not have been simulated otherwise

We call it "artificial reality"—the result of using computer graphics to produce images of objects that exist only as numbers in computer memory.

Computers are often used to control camera tracks; however, the camera is always directed at real objects or at artwork. Also, computers are used in analog techniques such as raster warping in video post-production. The computer graphics described in this article use state-of-the-art equipment and techniques. We define entire pictures digitally using mathematical models instead of physical models.

Many of the effects needed for the COSMOS PBS television series involved simulations of various scientific phenomena. Since science and mathematical modeling were central to the desired results, some of these effects were ideally suited for production using computer animation. Many conventional animation techniques, such as multiplaning, generate images that look three-dimensional by using two-dimensional artwork. Computer graphics has the advantage of allowing more explicit three-dimensional modeling of objects using analytic geometry. In terms of accuracy and detail, computer calculations are far more consistent than artists' conceptions of real objects. For example, some of the effects to be described in this article used a computer data base which holds sufficient information to calculate the actual location of 6000 stars. The computer can display those stars in any given frame accurately in three dimensions from any viewing direction. Few artists have the time, patience, or information to achieve this level of accuracy on every frame of an animation.

Although we made major attempts to maintain exact scientific accuracy in all of the COSMOS computer animations, we faced difficulties for several reasons. Some sequences represented physical phenomena which were too subtle to notice if simulated completely accurately; therefore, some controlled exaggeration was used to make particular points stand out. Also, several sequences involved phenomena which had been explained by competing theories; we had to select one theory to depict. Finally, in some cases, the physical data necessary were known only to limited accuracy and we made educated guesses to produce reasonable numbers to feed as input to the simulations.

The computer animations used in COSMOS were made by the authors and other personnel at the Jet Propulsion Laboratory (JPL), which is run by the California Institute of Technology, in Pasadena, California. In particular, the JPL Computer Graphics Laboratory was conceived and is managed by Robert E. Holzman. In addition to the computer facilities and graphics techniques, the scientific expertise at JPL proved to be highly beneficial.

The production of each computer animated sequence for COSMOS required several steps. Starting with an idea or rough design provided by KCET and accompanied by relevant scientific information, our first task in the development phase was to make sure we thoroughly understood the physical process to be simulated. Then we tackled two types of design. First, we designed the method of modeling the objects to be represented and determined what mathematics were required. Second, we decided how to structure the software; i.e., the computer programs and the data base upon which the programs would operate. We had to give special consideration to such factors as calculation speed and human interaction. Following the design, the last part of the development phase consisted of actually generating the data base and of coding and testing the software subroutines.

Once we began the production phase, we had to define the key frames of the animation in terms of mathematical parameters known to the software. Interactive graphics usually played a significant role in this step of the animation process. Given the key frames, the computer then calculated the in-between frames. Depending on the sequence, the computation phase ranged from hours to weeks of computer execution. Once the computations were complete, we created a computerized script and initiated a computerized filming process.

The computer-generated images for the animations fell into two major categories determined by the fundamental technique used. These categories are called vector graphics and raster graphics. Vector graphics has been standard until recently. The computer calculates the endpoints of a collection of line segments while a special purpose cathode ray tube (CRT) traces the lines in the order they are generated. Raster graphics uses a more nearly conventional television-style monitor without commercial (NTSC) coding of the signal. An image is divided into a rectangular array of dots or picture elements (pixels). The intensity or brightness of each pixel is controlled by a number calculated by computer software. Usually, vector graphics is used for line-drawing applications and raster graphics is used for color, shaded-surface images. New low-cost raster devices, which simulate vector graphics, have recently appeared on the market; however, they are not capable of the dynamics possible with high-performance vector devices.

Hardware used for high-performance vector devices is more expensive than for raster graphics, and vector images are more schematic but faster to generate. Because raster graphics allows colored and shaded areas, images can look more realistic, but can also be considerably slower to calculate. Certain computer animations for COSMOS were intended to be schematic and in black and white. For these sequences, we used vector graphics for economy and speed. Other sequences used raster graphics and were much more complex to program but gave a far more realistic and visually appealing result. Even for sequences rendered with raster graphics for the final product, we generated a schematic line-drawing intermediate version. The schematic versions served as "pencil tests" to preview motion quickly. Once the schematic version was finalized, then the color raster frames were computed.

The main computer used to produce the calculations is a DEC PDP 11/55. This computer interfaces with the two graphics display systems. For vector graphics, we used an Evans and Sutherland (E&S) Picture System which has special-purpose hardware for rapid three-dimensional transformations, such as translation, scaling, rotation, and viewing in perspective. Even with this sophisticated equipment, in many instances, the hardware did not have sufficient numeric precision to represent the large range of numbers encountered in astronomical phenomena; therefore, extra software was necessary to allow more accurate simulations. The raster output device we used was another E&S product called a digital frame buffer which consists of a large computer memory. One unit of memory (a "byte") is associated with each pixel to be displayed on a screen. As the main computer calculates values and stores them into the frame buffer, a subsidiary microprocessor continuously reads the mem-

ory and synthesizes a conventional video signal which is displayed on a CONRAC monitor. Our frame buffer stores 512 lines of 512 pixels each, equivalent to 256,000 pixels. Only 480 lines are displayed.

The final products of our computer animations are 16mm movies filmed by an instrumentation camera made by Automax. The camera sits on a tripod aimed at the display screen. Exposures are controlled by a shutter-dwell mechanism which allows time exposures for each frame of 1/2 to 1 second. By using such long exposure times, problems with roll bars from video monitors are eliminated. The main computer sends a signal to the camera to trigger the shutter after each frame is displayed on the screen. The camera sends a signal to the computer upon completing the exposure of one frame. As we were nearing completion of all of the COSMOS sequences, we purchased a relatively inexpensive (by industry standards) piece of equipment made by Dunn Instruments. The Dunn box contains an internal black and white raster monitor and is equipped with a Mitchell movie camera. Frames are automatically exposed in separations, using color filters.

All of our sequences were filmed on Type 7247 color negative film. The response of film to the phosphors of a display screen is not linear. A correction for this non-linearity can be included in the computer computations for the pixel intensities thereby achieving color compensation. This is a two-stage process. First, the sctual film response is measured under controlled conditions of exposure and screen brightness. A set of step wedges is exposed with known numeric values from the computer and the resultant density of the exposed film is determined. Second, these data points are entered into the computer which can then calculate the pixel value necessary to produce any desired film density. This technique will probably receive wider and wider application in many areas of the optical printing business.

It is important to note that all editing of the JPL COSMOS sequences was done in the computer prior to filming. We had to refilm only due to mechanical failures of the camera or to human error in positioning and exposure time selection. Frames generated using vector graphics usually took less than one second to calculate; therefore, we filmed this type of sequence frame by frame as it was computed. More complex vector sequences (up to five seconds per frame) and all of the raster sequences (30 seconds to nearly one hour per frame) were calculated and stored on digital magnetic tape over several hours or days. Later, the tapes were read by another computer program to film each sequence.

Altogether, JPL produced seventeen separate sequences for the COSMOS series for a total of approximately forty minutes of screen time. The sequences depicted different physical phenomena and used a wide variety of computer graphics techniques in their production. We used practically every previously established technique and invented new techniques, which constituted a research effort. New software was developed for each project integrating previously developed modules when appropriate. The remainder of this article treats some four sequences individually. We describe the simulations, techniques used, and problems encountered.

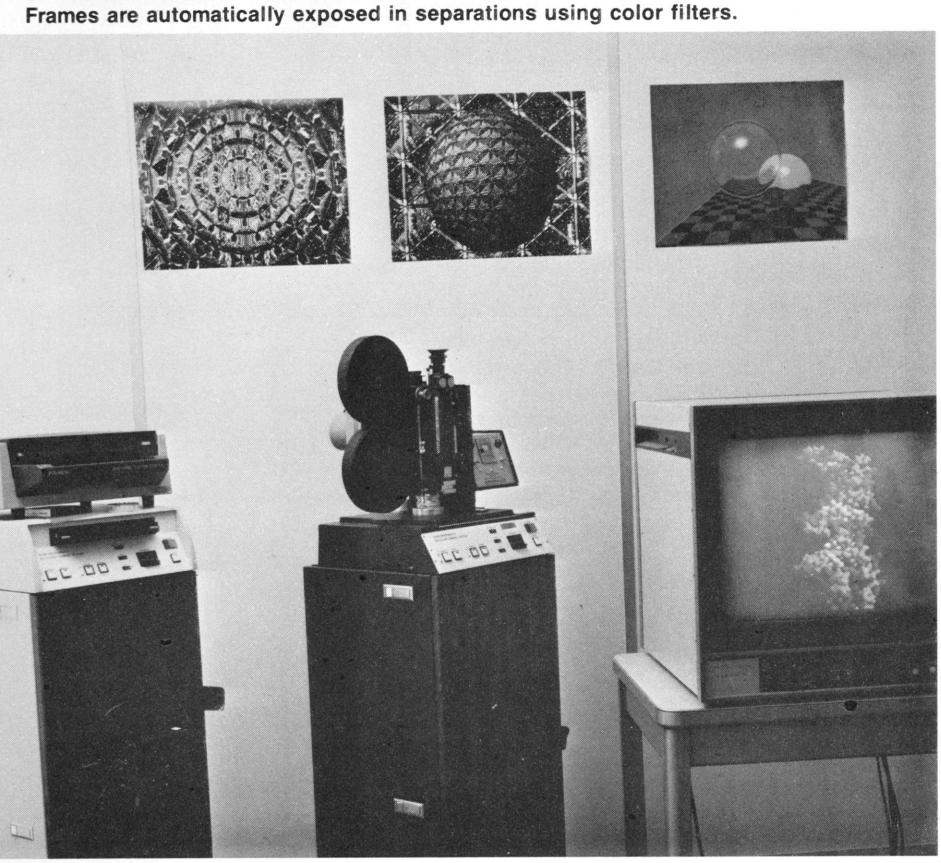
The first sequence that we produced simulated constellation time lapses. A constellation is shown as it appears today and as it changes over a million years both in the future and in the past. The development of the sequence involved searching star catalogs to find current precise star locations and distances from earth, proper motions (angular displacements per year), and radial velocities. A data base was defined and computer programs were written to convert these values into three-dimensional positions and velocity vectors for each star. Assuming uniform velocity, star positions could then be calculated for any time, future or past. Each star was projected and displayed as a spot of light on the vector graphics display.

The original intent of the constellation sequence was to show the time lapses for the Big Dipper. However, once the basic software was developed, we could fairly readily insert data sets for other constellations. We ran the program on the Big Dipper, Leo, Cetus, Gemini, Pegasus, and Orion, and we used all but Gemini and Pegasus based on visual appeal. Problems occurred when we discovered that the distance and velocity data for many key stars was not known to great accuracy; therefore, educated guesses were made. Finally, many stars in Orion are predicted to explode into supernovas over the future time simulated and new stars are expected to form in the Trapezium region near Orion's sword. New stars were programmed at random times and locations based on astrophysicists' current guesses as to expected density and position. Supernova explosions were programmed as very bright flashes with a few random radiating lines (a computer simulation of a star lens effect).

The raster graphics system was used for a sequence about comet history. Al-

Continued on Page 1052

A Polaroid and 35mm camera Dunn box and one with a 16mm Mitchell camera stand next to a CONRAC monitor displaying a DNA molecule. Overhead, on the left, are two pictures of computer art by David M and on the right is a computer-generated image by Turner Whitted of Bell Laboratories. The Dunn box contains an internal black and white raster monitor. Frames are automatically exposed in separations using color filters.



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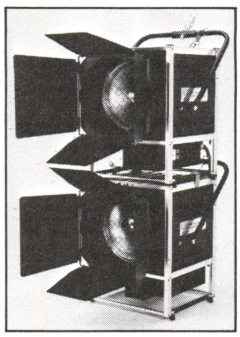

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Bill McManus (right) with Joe Tawil of The Great American Market, one of Cinema Products' major dealers for RDS/HMI 575W, 1200W, 2500W and 4000W Fresnel spotlights.

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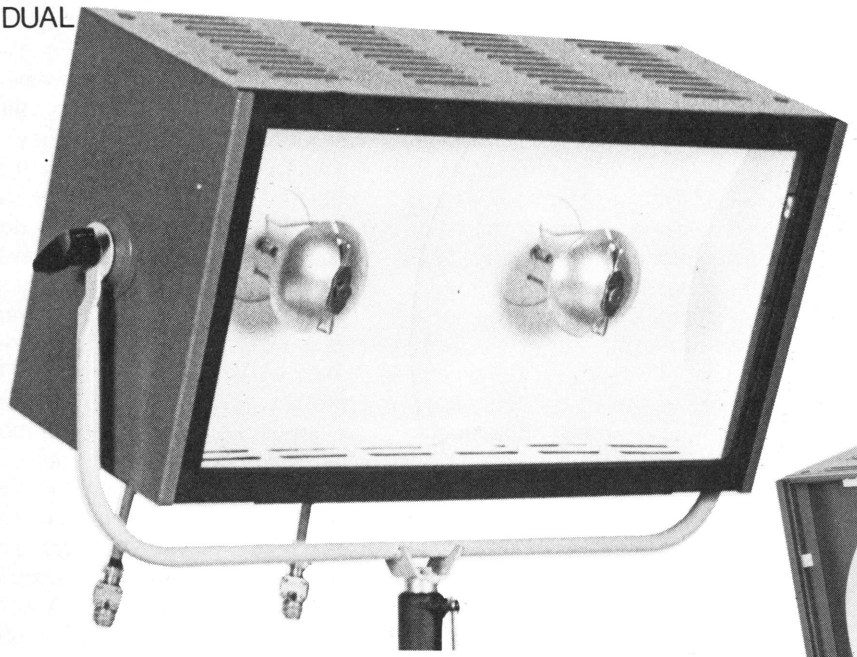

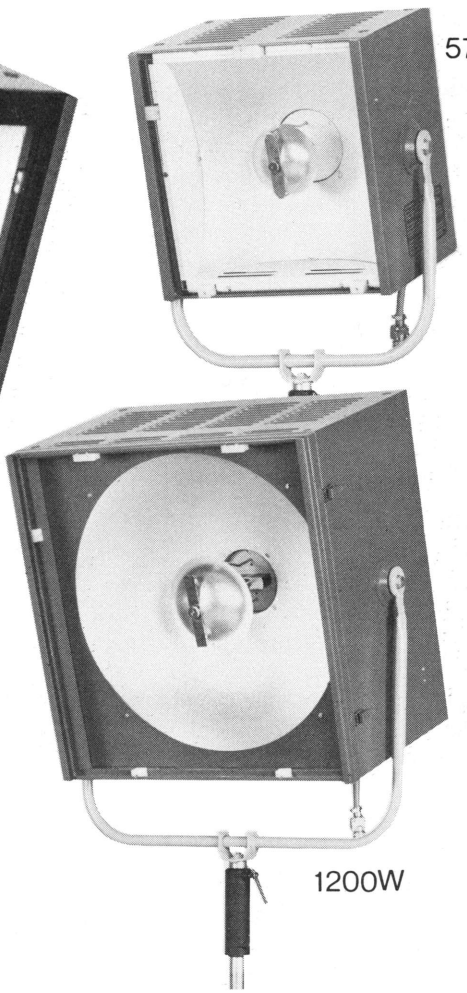

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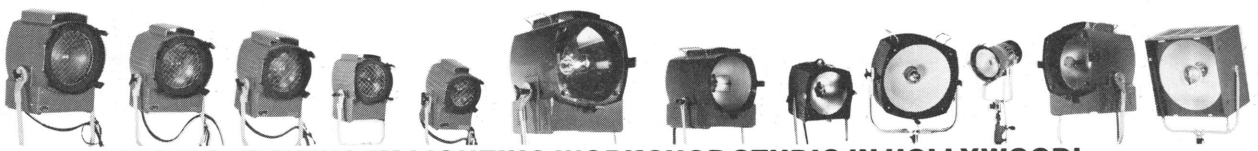

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"COSMOS" — A NEW VIDEO LOOK

Although the film portions of the series comprised more than two-thirds of the program material, in the end everything had to be on video tape

By CHARLEY W. LUX

Film or videotape? There is clearly a difference between the two "looks". In COSMOS we have a wide variety of both formats with the final product being on videotape. The preservation of the soft, feature-film look used in the 16mm location footage was a primary technical concern of Executive Producer Adrian Malone. He was most adamant that the final product not have that "hard video look". The resultant concerns over how the video sequences were to be shot had to be extended to include the transfer of the film portions to tape as well. The spaceship sequences (a video shoot) were the ultimate test of this blending of video and film, in that the window on space was actually front screen process projection of the 35mm special effects, using a projector that did not exist prior to COSMOS.

The film portions of the series comprise more than two-thirds of the total program material. They include the 16mm location footage (over half of the entire series), Oxberry stand and other animation footage in both 16 and 35mm, and the primary 35mm special effects. The spaceship sequences comprise the largest chunk of the video portions, followed closely by the Magicam special effects, and a number of studio "limbo" locations, also shot on tape. The mix of these elements varies from more than 90% film in a couple of episodes, to 75% video in another.

A number of different approaches were taken to keep the aesthetic picture quality of the video images as close as possible to that of the 16mm location footage. To begin with, the electronic enhancement of the video images was kept to a minimum, thus eliminating that artificial sharpness so characteristic of a video production. The use of state-of-the-art camera technology, whose naturally sharp pictures made this a painless sacrifice, also facilitated the use of fog and diffusion filters to further soften the conventional video look. Increases in camera sensitivity allowed greater freedom in choosing contrast ranges and shooting with key light levels as low as 30 footcandles.

In the spaceship sequences, with the front screen projection, we shot with key lighting as low as 20 footcandles. Even with modern cameras, increasing camera sensitivity for that low of a light level increases electronic noise undesirably. Noise is the video equivalent to film grain. In shooting the spaceship in such low light levels we committed ourselves to electronic noise reduction of all spaceship portions. The noise reduction worked equally well on both film grain and electronic noise, with the end result being nearly identical noise/grain characteristics for the two sources. We also used noise reduction for the entire film transfer process, eliminating much of the graininess inherent in 16mm film.

The use of projected 35mm special effects as the central element in the spaceship video shoot was, by far, the biggest technological challenge of the series. The 12′ X 16′ front window of the spaceship actually looked out onto a 20′ X 34′ projection screen, 20 feet behind it. The spacing and size were set such that the portion of the image seen out the window would change as the camera moved within the set, thus using parallax changes to give the illusion of three-dimensionality. The fact that this projected image was to be seen framed by a rock solid set necessitated the kind of capability found only in conventional pin-registered process projectors. The extremely large screen size not only enhanced this problem, but radically cut the available light.

A pin-registered process projector runs at 24 fps and shutters once per frame, with the shutter synchronized with the camera shutter. The result is 24 shutters/sec. However, a video camera runs at 30 fps and each frame is actually made up of two separate scans, or fields as they are called. The net result is a scan rate of 60 fields per second resulting in 60 shutters per second with two shutters per frame. Exit the possibility of a conventional process projector.

The only thing immediately available that might work was a conventional Geneva movement projector running at 30 fps. With a standard two-bladed shutter we got the necessary 60 shutters per second, but the picture instability (for a 34′ wide picture) was around 1½″ of peak-to-peak (p-p) vertical jitter—painfully obvious when framed by a hard set and as a background to a person within the set. That left us with nothing.

The Geneva test did give us the opportunity to set some sort of criteria for what would be acceptable in terms of stability. After all the final product was to be seen on TV and with a 25″ viewing screen did we need absolute perfection? As even a pin-registered movement would allow nearly 1/8″ p-p movement for our size image (a 1″ wide frame magnified *416* times to a 34′ picture) we settled on a specification of ¼″ p-p movement for a 34′ picture. This translates to a film plane registration of ± .00025 inches.

Mitchell camera thought that they could manufacture the necessary movement, but due to the extreme degree of precision required (it would have to run 2½ times faster than a conventional pin-registered movement) they wanted at least six months; too long and too costly for us. La Vezzi, manufacturer of Geneva movements, thought that they could give us an ultra-precision Geneva movement that would come close to our specifications, but most likely to only a ½″ p-p jitter on our size screen. They also wanted at least six months and the degree of precision was only marginally acceptable.

Newly introduced by RCA was a projector that used an electronic pulldown, and optical sensing of the film perforations for registration. If tweaked to perfection, this projector just might meet our specifications. We decided to go for it, but production line delays and back up of orders for it once again put delivery too late for us, with no real performance guarantees. Back to square one.

Enter L. Ron Schmidt, who had done the initial design on the RCA projector and worked on a variety of precision special effects camera movements (STAR WARS, STAR TREK, THE BLACK HOLE). He had combined the electronic pulldown and optically registered movement with vacuum chambers ahead of, and behind the gate attempting to achieve even greater registration accuracy. After agreeing on some rather complex specifications and production deadlines, he turned his half-completed, vacuum cleaner-powered, test unit into a running prototype projector in less than six weeks, proving that it was possible to meet the required specifications. He then proceeded to build a one-of-a-kind precision projector displaying a degree of craftsmanship seldom found in any business.

In working closely with Ron on laying out the control functions, some rather amazing features developed. The projector, run by servo motors and miscellaneous sensors is controlled by a microprocessor (a small computer). As a result, once pulldown and registration specifications were met for 30 fps operation, several other options became sim-

ple computer software modifications. For example, the shutter was two-bladed, running 30 revolutions per second, giving the required 60 shutters per second. For 30 fps operation pulldown was triggered every other shutter. Triggering pulldown alternately after three shutters then two shutters gives the 3/2 pulldown required for 24 fps operation into a 30 fps system.

Next a 3/3 pulldown was added which gave us a 20 fps option. With a dead accurate digital frame counter we provided precise cueing to any desired frame number and the pulldown in this cue mode done after each shutter, giving a 60 fps speed. The result was fully locked, stable, and synchronous projection at 20, 24, 30, and 60 fps—not just in forward, but reverse also! These options became prerequisites during the production.

While the projector was being finished, a lamphouse had to be decided upon. Our initial projector test, with a camera and a 34′ screen utilized a 4,500-watt xenon lamphouse which was marginally acceptable straight, but too low when color corrected down to 3200° kelvin (xenon lamps have 5400°K color temperature). A high-powered carbon arc was considered, as its color temperature was much closer, approximately 4000°K, but stability of arc, venting and ease of operation made it less desirable.

With much assistance from Optical Radiation Corporation a special 6000-watt xenon projection lamp system was put together. The color temperature problems were handled by two methods. First, the conventional heat filter (actually an infrared mirror) was replaced with a "solar simulator" filter that still cut out most of the infrared, while minimizing visible red loss, as well as cutting the blue end of the spectrum somewhat. Secondly, all the prints were then timed with special offsets to bring the projected image down to the 3200°K, studio color temperature.

When I brought this 6000-watt lamphouse over to Ron Schmidt's for marrying to the projector, we introduced a somewhat larger problem than we anticipated. Six thousand watts of light thru a 3/4″ x 1″ aperture is a little much, to say the least. We found early on that if the film happens to stop with the douser open, a perfect 3/4″ X 1″ hole is punched (vaporized) in the film. This happens so fast that the sprockett holes are left perfectly intact (no need to splice if you don't mind a flash frame). Special high-speed dousers were added to the projector to guarantee film integrity. Extra fan blades were added to the shutter itself for increased shutter and gate cooling and maximum continuous full power operation was limited to eight minutes, or one full reel (the projector's capacity was 1000′ on a 3″ core).

In operation on the stage, even with a two-times gain screen, the key lighting for the set ran between 20 and 30 footcandles so as not to over-ride the front window effects. Highly sensitive cameras and a commitment to down-stream noise reduction made it work.

Since video is poorest at resolving low-light or near black detail (electronic noise is most apparent there) the prints used for transfer, as well as those used for on set projection, were made slightly less dense by about 1/3 stop. For normal projection these would look a little milky, but through the camera chain (be it studio camera or a film chain camera) black levels can be set independently of white level. Thus, any low light element can be arbitrarily called black. Also, the actual transfer curve, from black to white is adjustable; this particular control is termed gamma correction and allows low-light detail to be either compressed or stretched. The result is independent, while level (iris or gain), gamma, and black level controls. Superimposed on each of these are red, green and blue "paint" controls. These are somewhat akin to timing lights in color correction of prints. As you may see this gives much greater latitude in color correction, but with a corresponding increase in complexity.

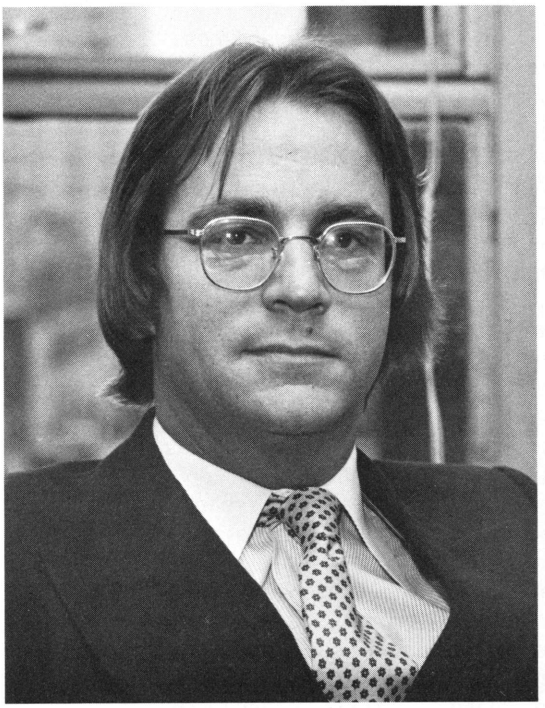
When the film sequences were transferred to tape, a Rank-Cintel flying spot scanner was used. This allowed for the highest quality transfer, the smoothest handling of the prints, and the greatest ease of color correction. The latter was accomplished using a scene-by-scene correction option whereby each scene's correction parameters (the 12 mentioned above) were stored in a microcomputer according to frame number and then the entire reel played back and recorded in one pass, letting the computer do the work. These changes can also be programmed in as a dissolve coincident with lab dissolves already in the print.

With much care having gone into the video look of both the straight video sequences and the film transfers, it became important that video continuity be continued through the editing process. Greg Harms, the Video Engineer for all in-house video work on COSMOS, was also able to be the assistant videotape editor allowing for the optimum video continuity. This was most helpful given the varied nature of the source material within each episode.

While a variety of technical compromises were made to ensure continuity of over-all picture quality, the final product encompasses one of the widest dynamic ranges yet attempted in video. Video technology has improved dramatically of late, giving us the freedom to add an increasingly artistic dimension to what began as an "optimum-picture-only" medium. The video signal path is a complex one, however: from camera, to tape, to many generations of tape processing, to satellite, to receiving dish, through a broadcast station, a microwave link, a local TV transmitter, through the airwaves, to your home receiver, and most importantly, through your personal settings of "brightness, contrast, color and tint." All of these elements can rob a video signal of much of its sublety (which is why it began as optimum-picture-only). Modern-day electronics, however, keep these losses to a minimum, and with luck, most of what we have struggled to put on tape will make it faithfully into your living room. ■

KCET's newly installed Grass Valley switcher allowed COSMOS to achieve many diversified video effects that would have been prohibitively expensive had they been created elsewhere. Here Technical Consultant Charley Lux takes the system through its paces. A unique pin-registered process projector was designed and built for the series.

John Wilcox says, "ECLAIR cameras have been the exclusive workhorse of ABC SPORTS Emmy Winning Team."



John Wilcox
Director of Film Production and Development
ABC Sports
Producer, The AMERICAN SPORTSMAN
Spirit of 78: Flight of the Double Eagle II

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A VIEW FROM THE KITCHEN

Despite all of the electronic and computerized magic of modern special effects, some of the most impressive for COSMOS were created "by hand"

By DOV JACOBSON

These seem to be feverish times in the special-effects business. Ever-more complex motion control systems are springing up all over the place. Enough camera track is being laid to start a decent mass transit system. Computers are being wired into servomotors and video screens. And the stunt pilots of vector space are off and flying. It seems that the film business is being infected by its sister industry in Los Angeles, the defense industry, with a consuming fascination with "high technology". And like the defense industry, it seems only capable of conceiving projects on the most massive scale, complete with tight security, cost overruns, and an increasing reliance on sophisticated hardware rather than human ingenuity and skill. Of course, it's exciting that these machines can create magnificent new visual effects (and perform certain routine operations with great efficiency) but this should not eclipse the fact that there are still some things better done by human beings using their hands.

For example, of all the deservedly celebrated STAR WARS effects, none surpassed the clinging electricity bolts that paralysed R2D2 (shown during the Academy Awards ceremony). This effect was simply animation, hand-drawn by the late Adam Beckett.

So when my partner, Judy Kreijanovsky, and I signed on to produce a variety of effects and animation for COSMOS it was a pleasant surprise. They (Greg Andorfer, Susan Racho and Jon Lomberg) were interested in producing a mixture of hand, mechanical and electronic imagery; and they were comfortable working with individuals as well as corporate entities. Judy and I approach animation as a cottage industry: our studio, the Cartoon Kitchen, is a Mom and Pop operation in our home. Yet our work has to stand alongside that of Paramount's Magicam, Universal's Hartland, JPL's computer animation group and other megabuck studios.

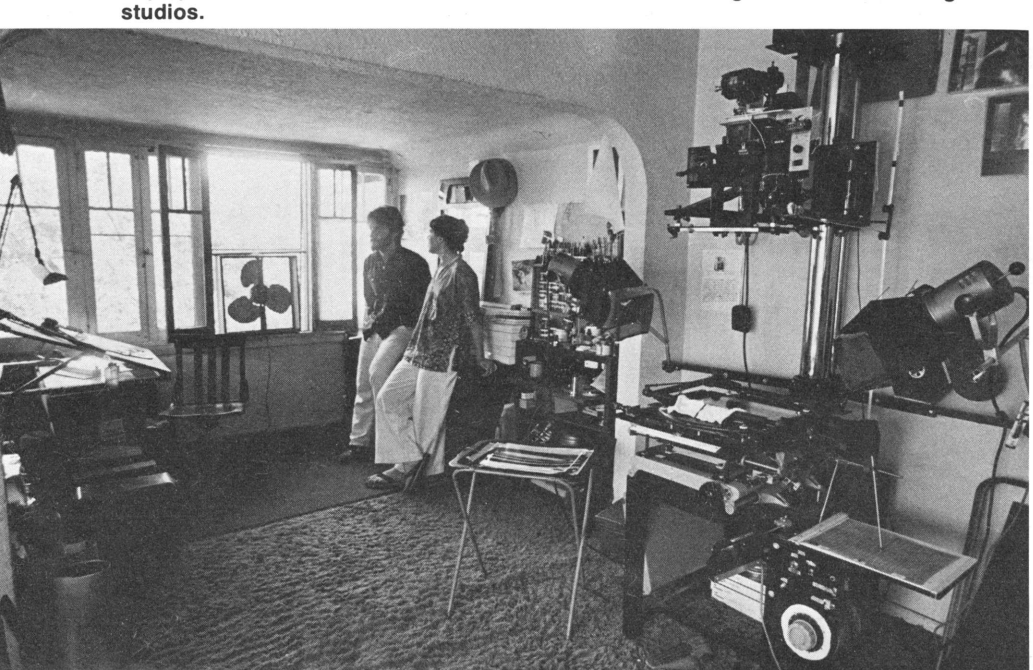
There are distinct advantages to working at the scale we do. For one thing, we were able to produce about 5% of COSMOS's effects footage while consuming less than 1% of their effects budget. When the same hands design the scene, lay out the animation, paint the cels and operate the camera, it lends an efficiency to the operation and a unity that, I believe, is reflected in the final footage. There is another important advantage to working as a general animator with a simple, adaptable animation stand. When you've invested heavily in specialized equipment, you have bound yourself to a specific style of effect. In order to amortize the machinery, you have to apply the same solution to every problem. Form follows hardware; and, *voila!,* the "streak" is now the most overused effect since the invention of the zoom lens.

With our set-up we could shift around between (and usually blend within a single shot) a variety of techniques: cel-animation, light-effects, model work, kinestasis, painting-under-the-camera, rotoscope travelling matte work, and "human-interfaced motion-control" (where we used a programable calculator to work out all the settings for complex moves and then operated the camera digitally—that is, we used our fingers). So it might be interesting to mention a few specific problems that came up on some shots and the solutions that were found:

The Black Hole: Greg Andorfer asked us to animate a Black Hole or more properly the "accretion disc", the collection of gas and stellar trash that orbits around the hole on its one-way trip to nowhere. Greg insisted that our Black Hole should rival that of a somewhat better-known animation studio which had just released a $20,000,000 film centered on a Black Hole effect. Suggestions that were made on how to render the effect ranged from spinning paintings at acute angles under the camera, to rotoscoping ink being flushed down a toilet. These model techniques have the advantage of convincing photographic realism, but the drawback is that you must settle for a simplified mechanical analogue of a complicated and subtle phenomenon. For example, the intense gravity of a Black Hole can bend light, so the hole itself acts as a peculiar kind of lens, distorting its own image. This would be difficult to duplicate with mechanical and optical effects, as would such other phenomena as the magnetic lines of force around the hole, or a shock wave, a sort of spirallized Malibu breaker of gas that accentuates the inner vortex. There are even three independent overlapping regions of color shift: a rise in color temperature that corresponds to a rise in physical temperature as the gas gets closer to the center; a (Doppler) shift in the color of the gas as it spins toward and away from the camera, and finally a redshift right near the hole as intense gravity stretches the wavelength of the last bit of light. So the effect was rendered as hand animation, resulting in a stylized schematic effect —quite appropriate for an object that has yet only been observed on physicists' blackboards.

Separate animation cycles were made for each of eight regions of the Black Hole. The cycles were airbrushed abstract swirls of various specific forms. Some were based on the computer maps of a French theorist; but most were worked out strictly by eye. (The perspective didn't allow compasses or templates.) All the cycles were then burned onto the same piece of raw stock.

The cartoon kitchen studio (after having been cleaned up specially for the photographer). Why would one think that it's not like this all the time? Mainly because it's a very busy place. The author and his partner approach animation as a cottage industry, a Mom and Pop operation in their home. Yet their work has to stand alongside that of the "megabuck" studios.



The final problem was that short cycles of animation can result in repetitive and dull motion. The solution to this problem came while listening to a Phillip Glass composition. Glass (like Steve Reich and other composers of the last decade's *avant-garde*) superimposes cycles of slightly different periods to achieve complex rhythms and textures, as the cycles go in and out of phase. Translating this technique to animation, it was possible, in only three passes, to convert a ½-second cycle (12 cels) into a complex pattern that takes well over a minute to complete and has about 500 distinct frames.

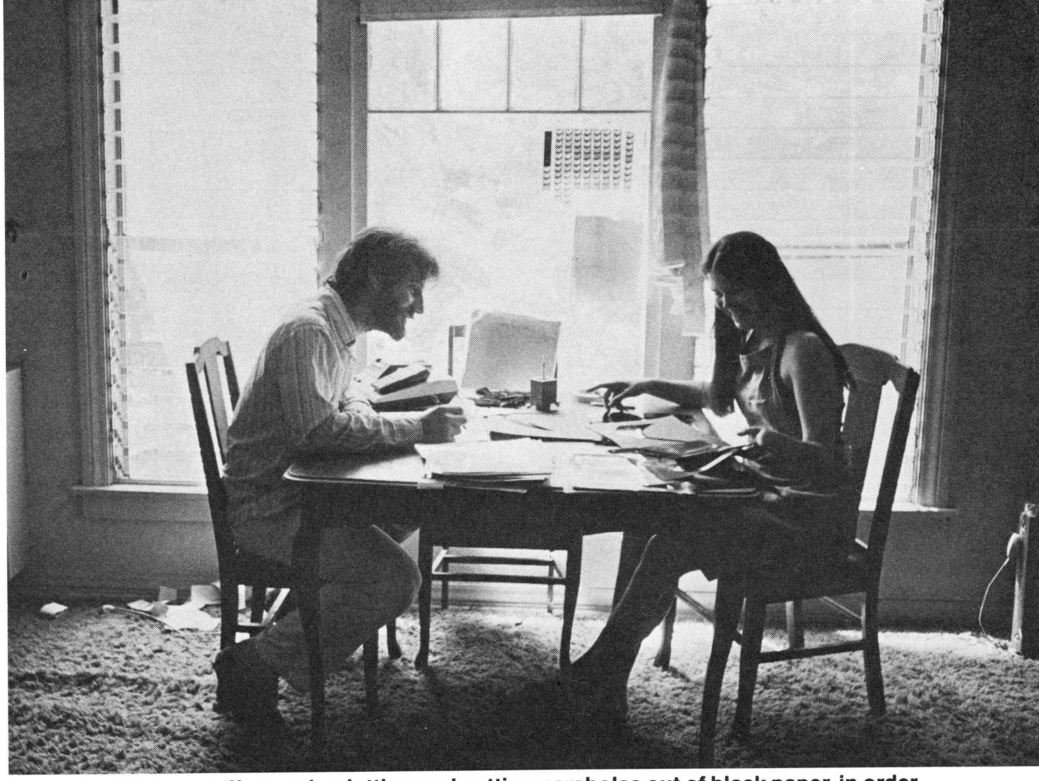
Retrograde Motion: For this scene we animated the apparent paths of the planets across the sky, to demonstrate the clues that led Kepler to his discoveries on the nature of the solar system. Particular emphasis was on the "retrograde motion", a periodic occurrence when a planet suddenly appears to reverse its direction for a month or two. While this could have been done with computer animation, it probably would have taken longer (and certainly would have been more expensive) to set up the computer algorithms to just go through by hand. More importantly, a CRT image is simply not as smooth and rich as a good Kodalith line, underlit with color gels and with just a tiny tad of diffusion.

So, after hunting through a few decades of ephemeris tables to find a period in the 1940's when all the planets retrograded in the same part of the sky, Judy patiently plotted the positions of five planets over five years. Under the camera, using both "scratch-off" and "paint-out" techniques, she animated little circular planets swooping across the screen, leaving behind graceful looping trails of color across the stars of the zodiac.

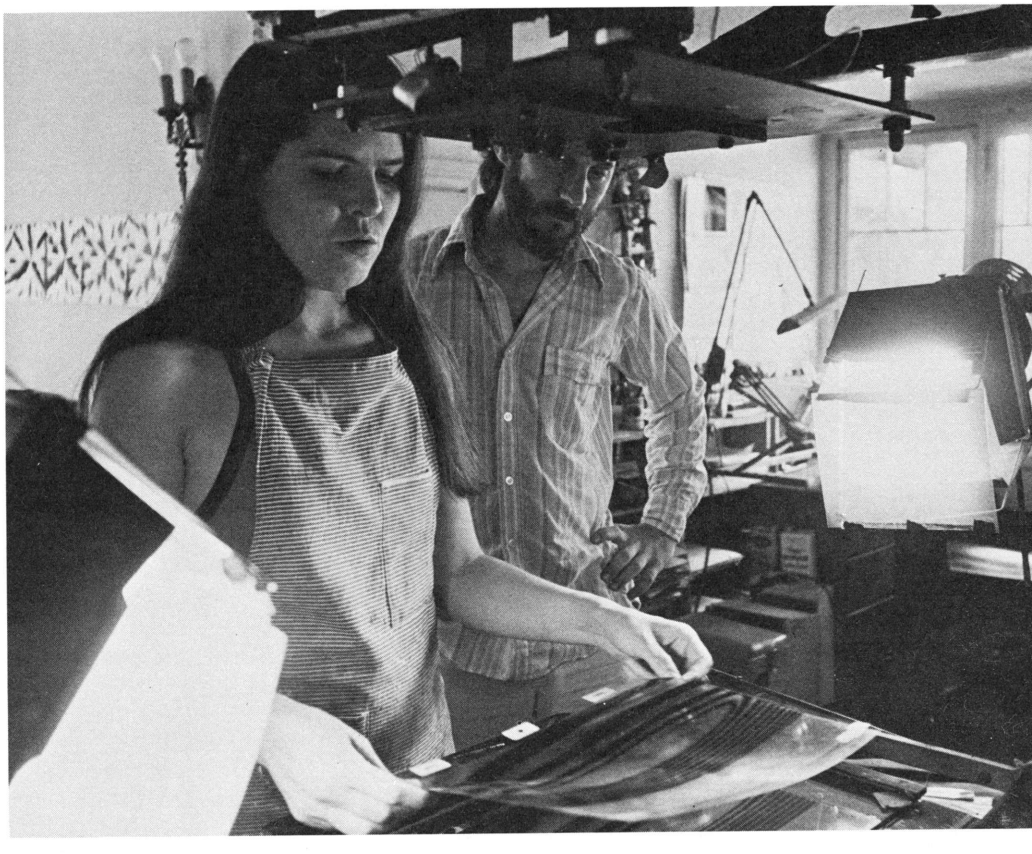
The Dysonsphere: This scene shows an advanced civilization of gung-ho super-engineers who are constructing (as suggested by physicist Freeman Dyson) a shell of meteorites and planets to completely enclose their sun; thus trapping 100% of its radiated solar energy, rather than the tiny fraction that falls on a single planet's surface. We had to animate this "Dysonsphere" under construction, including a lot of meteorites being rocketed into position. So far, no problem.

But Jon Lomberg felt that the most dramatic impact of this scene would come from creating a sense of deep space between the camera and the Dysonsphere, thus indicating the tremendous scale of the project. It is debatable whether the illusion of depth can made convincing on a television screen; with its tiny size, its poor resolution, and particularly, its disillusioning viewing conditions (lighted rooms, oblique viewing angles, and the simple obvious fact that the image is sitting on the surface of a box). To obtain any sense of depth, perspective must be forced to the utmost. So we ended up adding to the scene a planet that looms up from below the camera, so close that its horizon is nearly a straight line. As it recedes toward the construction (trailed by a sister planet) it is visible as a sphere, that diminishes to a tiny dot by the time it reaches the Dysonsphere. This required a change in scale of over 2000:1, which as far as I could calculate would necessitate a track a

Continued on Page 1056



The entire kitchen staff at work; plotting and cutting parabolas out of black paper, in order to animate a beam of light bending under intense gravity. (BELOW) Judy Kreijanovsky works the animation stand, while Dov Jacobson looks on. The rig is comprised of a Bell & Howell 2709 camera mounted on an idiosyncratically modified Fax Sr. stand.



The Arriflex 16SR High Speed: It's quiet.

At 24 fps, it measures 32dB. Same features, same accessories, same on-board battery as the standard 16SR. Switched on, it gets up to 150 fps in under two seconds. Even at *that* speed, it measures only 56dB.

John Nicholas directed the official film on the Lake Placid Olympics. "Some locations the crews had to ski to," he says. "At others, officials put everybody in one spot. Or the terrain restricted angles. Yet we needed something different from the TV coverage. Our 16HSRs gave us the equivalent of two cameras at each position: high speed *and* sync sound. They did double duty."

Three feet from the film plane, the 16SR High Speed (the 16HSR) measures 32dBA at 24 frames per second. That's quiet enough to shoot sync sound on location, in most cases.

At the same distance, the 16HSR measures 56dBA at 150 frames per second. That's quiet enough to shoot a tennis serve without getting thrown off the court, or a golf swing without being clubbed by the player.

Runup power is supplied to the motor in linear fashion, compensating for load. No jerks. You can start at 150 fps if you want to. And the 16HSR will run at exactly the speed you set, crystal-controlled. No need to watch the tachometer.

Whatever frame rate you choose, the 16HSR gets to it in under two seconds. The camera doesn't waste film running up. *You* don't waste film by switching on early to be at speed when the action happens.

With 10-100mm Zeiss lens, 400 foot magazine, on-board battery and variable speed control, as shown here, 16HSR weighs 16¾ lbs.

The 16HSR has same features, uses same accessories, is powered by same on-board battery as a standard 16SR.

You can change the 16HSR's coaxial magazine in about five seconds. And you can unload and reload it in less than four minutes. Except for the pressure plate, the magazine is the same as the one on the standard 16SR. (But they're not interchangeable.)

The variable-speed control unit mounts on the carrying handle. It's on a swivel base, so you can turn and tilt it in any direction. Wherever you put the viewfinder (left side, right side, front, back, up, down), you can see the switch positions and frame rate readout.

On the unit's front, there are two switches, a knob and an LED readout. The knob sets the speed. One switch turns the camera on and off. The other selects variable or sync speed. On the back are two more switches. One sets the LED counter to 24 or 25 fps. The other selects 16 or 35mm. (You can use this control unit with *any* ARRI crystal driven camera.) 10 to 150 fps on the 16HSR. And you can change from sync to variable speed *during the shot.*

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"COSMOS" IN POST-PRODUCTION

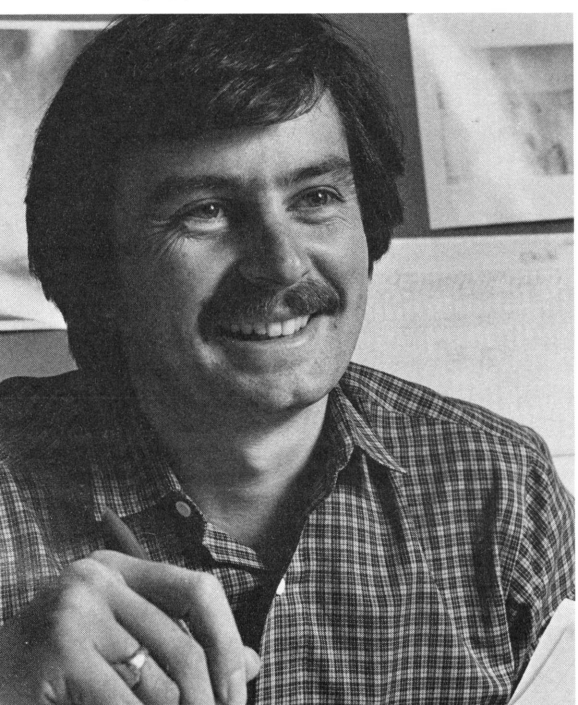
When the shooting stops, the task of putting it all together begins and in this case it was a jig-saw puzzle involving many techniques

COSMOS POST-PRODUCTION: AN OVERVIEW
By GEOFFREY HAINES-STILES
Senior Producer

Many times, the post-production staff may say, "the show was made (or saved) in the editing room." While that's almost always an exaggeration, it's certainly true on nearly every major series that many creative decisions do get made in post-production. Of course, these must relate to, serve and enhance the original intentions of producers, writers and directors when setting off to record the initial material. But, certainly on Cosmos, BOTH technically and conceptually, post-production was characterized by imagination, flexibility, coolness under fire and old-fashioned stamina, as we slogged through the vast wealth of sound and picture elements banked in over a year's worth of filming and taping for the 13 one-hour shows.

The presiding genius of the editing area was Jim Latham, on leave from the BBC. He had worked previously with Executive Producer Adrian Malone on *The Ascent of Man* and *Age of Uncertainty,* and more recently with Producer David Kennard on *Connections.* But this was the first occasion on which he was the only film editor to work on every show in a multi-part series. Perhaps daunted by this fact (but probably not) he had sent veteran Hollywood Post-Production Supervisor, Bea Dennis, a "shopping list" of required editing needs before his arrival from England. It included such things as "bobbins" and a "competitor." Bea, as is her wont, swore a little bit, went out to lunch and then picked up the phone and tried to translate these into American film language. Obviously, it turned out not to be too hard to provide film *cores,* but in fact, the Acmade Competitor synchronizer, with four magnetic sound heads and one picture head did have to be shipped in, through apparently its use in America is now becoming more common. Malone also continued to talk about "rostrum camera" for stills-animation work, but all in all, the language and technique of film proved relatively universal, as we also discovered when our Japanese and German co-producers came to screen rough cuts.

Senior Producer Geoffrey Haines-Stiles feels that COSMOS post-production involved imagination, flexibility, coolness under fire and old-fashioned stamina.



Latham's talents extended far beyond the skillful cutting together of film images. The musical complexity of the series, from Rimsky Korsakov to Pink Floyd, from classical and ethnic pieces to extensive electronic and synthesizer scoring, derives largely from his storehouse of arcane references—ably abetted and updated by the even more arcane knowledge of music consultant Gordon Skene, who would, from time to time, raid record stores in Little Tokyo for unpronounceable composers and artists, with stunningly surreal and beautifully "science-fictional" offerings. Like other major PBS series (previously produced by the BBC) many sequences were conceived of, and cut to music, even at the rought-cut stage, with Latham often running two and sometimes three audio tracks to ensure that the emotional tone of a sequence matched its content. In addition, music was considered an integral element of the series from the beginning—Carl Sagan having been the moving force behind the record of *Earth's Greatest Hits* placed aboard the two Voyager spacecraft now travelling toward the stars. In COSMOS, the thematic use of music was perhaps carried to an even greater extent than in previous series. For example, the *exploration* theme (Alan Hovhannes' 19th Symphony), the *atoms* theme (from Vangelis' "Albedo" album) or the DNA theme (Pachabel's Canon).

Given the ambitious breadth of the series (effects, location dramatic *and* documentary filming, Magicam and studio taping)—spread over many countries, studios, months and changes of show content Bea Dennis and her staff (Ramon Romero and Don Wylie being "lifers" for the duration of the project as assistant editors) did an excellent job of cataloging and coding what one calculation put at 50 miles of film—16mm and 35mm, stock footage from sources all over the country and abroad, from university labs and solar observatories, of whales and amoeba, Japanese blood and New York's 3rd Avenue "Elevated," and much stills animation. Flexibility was again the keynote, because in the grand cosmic jigsaw puzzle, sequences were constantly being reordered within programs, even juggled from one program to another, for time or other considerations. In this, an initially confusing jargon was sometimes of help and sometimes a hindrance. "Anyone seen the Aztecs?" "Oh, I think they're in the Graz Armory sequence." "In 3?" "No, in 12." "Well, I think we want them for 13." "Oh, . . . O.K." And that's the way it was.

It's also fair to say that there was an organic development to the series, as in the growth of Topsy. Although Malone and Sagan had from the beginning very clear ideas of what the series should look, feel and sound like, the review of material already shot dictated changes in length, style and content of sequences not yet committed to film or tape. One negative aspect of this was that until relatively late in the process, no complete show was totally assembled. While some episodes were almost entirely on film, most were a curious hybrid of location, "limbo studio," Spaceship, Magicam, stock and stills—hence the concern for continuing options and sometimes infuriating re-thinks by the producers! Hence the technical design of the audio post-production process (see accompanying articles by Gerald Zelinger and Kent Gibson) and the life-saving utility of the additional graphics potential of Roy Stewart's 1" CMX 340 videotape editing set-up (see sidebar).

As of the writing of this article—mid August—there were still three release prints to be accepted, three entire shows to be video edited and five shows to be sound mixed. We plan to deliver at least Episode 13 after the September 28 premiere of Program One run on PBS, so it is quite clear that much remained to be done relatively late in the game. And it's fair to say that, as in so many other areas of COSMOS, post-production came to rely on very sophisticated electronic equipment (as well as the old six-plate Steenbecks and upright Moviolas and a

KEM) and has motivated the talented staff to develop new systems and techniques to take advantage of the potentials which state-of-the-art machinery permits. I guess we're now really ready to tackle a multi-million dollar multi-part series! What will be next? ■

COSMOS AND THE CMX 340 SYSTEM
By ROY STEWART
Videotape Editor

One-inch videotape machines gave post-production on COSMOS very much faster and simpler ways to achieve a final product. The COSMOS project was the first project at KCET to utilize the new production techniques that the one-inch machines offer, such as the ability, without generation loss, to create special effects by tape speed changes from minus one-fifth speed up to two times standard speed, or freeze frames while recording these onto the edited master.

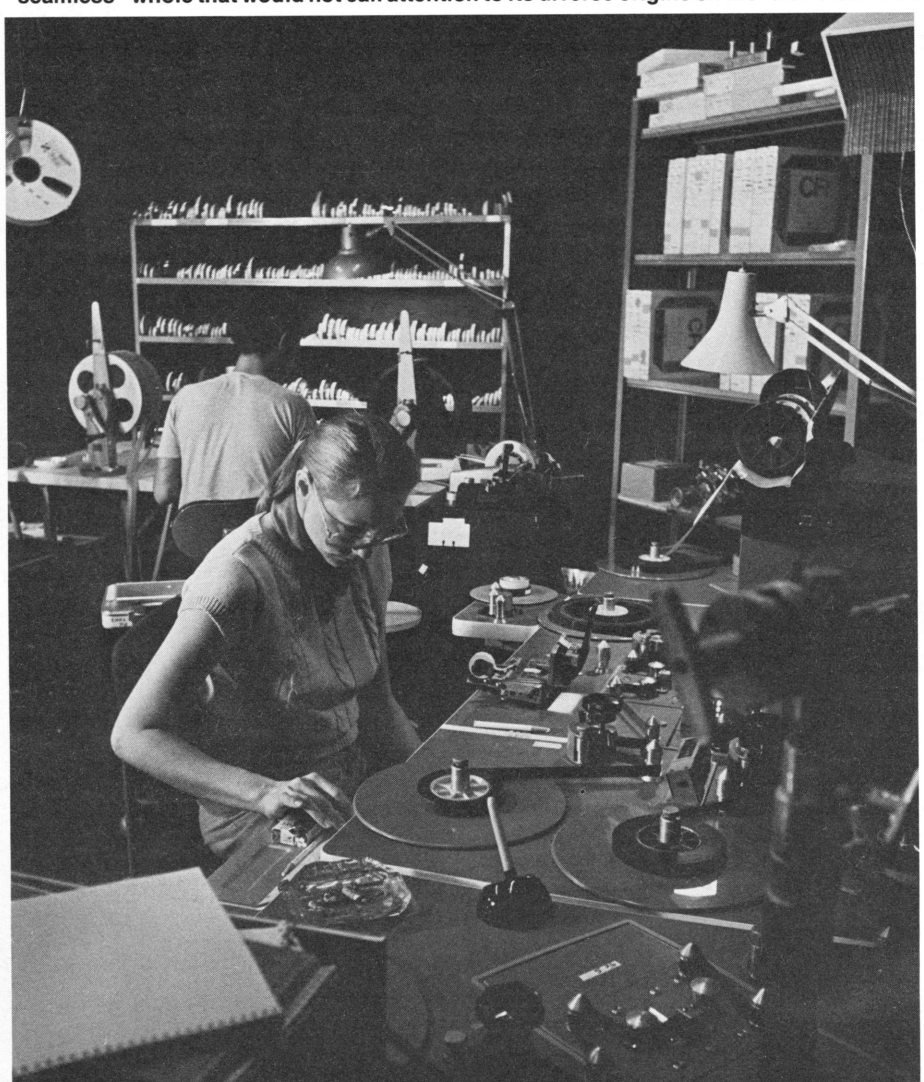
It is apparent that the time which can be saved on opticals is astounding. At the editor's console, one can make any necessary special adjustment to achieve the desired look or transition with no quality loss. Use of the CMX 340 system allows the director the freedom to choose any rate of dissolve from a cut up to eight and a half seconds via computer control. These transitions can be rehearsed and rehearsed until the proper effect is achieved. It is also possible on CMX (but not automatically) to do extra long dissolves and to change the apparent look by lowering of the intensity of the signal. The superimposition of colors, such as sepia tone, can add aesthetic value to the picture, as we did with the history of Robert Goddard's development of rocketry.

The use of specialized computer programs greatly accelerated the process. These programs (called "409") reduce the final editing first pass to exact edge numbers, thereby eliminating all overrecords and areas that were recut, but not in the final print which makes subsequent changes very easy to accomplish.

By using the "TRACE PROGRAM," one can make as many recuts of the same material as desired and then come back to the original edge numbers to conform with the final print without any generation loss.

In summary, if COSMOS had been done on two-inch, the show would have suffered greatly from the inherent two-inch velocity error which causes the banding noise which is absent on one-inch. Also on two-inch, speed changes would have had to be done via HS200 disc machines, which only store information for thirty seconds and cause generation loss, and do not provide the director with an immediate preview. Also, one-inch machines can display a picture all of the time, even in rewind or fast forward. Two-inch machines show a picture only during play, which slows down the editing process tremendously. ■

Assistant Editor Ruth Byrd at work on the KEM editing console, with Assistant Don Wylie engaged in the endless task of trim filing. The enormously complex editing process on COSMOS involved the smooth blending of 16mm film, 35mm film and video tape into a "seamless" whole that would not call attention to its diverse origins on the television tube.



"RETROFITTING" KCET FOR AUDIO POST-PRODUCTION
by GERALD ZELINGER
Sound Mixer

Production had begun in the spring of 1978. COSMOS was becoming a reality. It was considered to shoot it all on videotape . . . locations, studio, everything. I thought how wonderful it would be to do a television program like this and really care about the sound—maybe even stereophonic sound, at that. We talked about audio becoming involved with the project from the beginning so that the sound elements would be considered from the outset and not just as the afterthought that so often happens.

As it turned out, the locations and many of the special effects were produced on film with videotape used for studio segments and Magicam, with final assembly onto 1" format videotape.

It was decided that because so much of the program would be on film that film elements should be handled in that technique, but that the program would be conformed on videotape and mixed in that format. How does one combine these elements and still allow for flexibility? We would have as many as ten magnetic film elements edited to sync with picture, and yet we did not want to pre-mix them and then just edit them into videotape segments. We wanted to combine techniques and incorporate the best of both.

Before COSMOS, KCET did not have 1" VTR facilities and had only limited multi-track audio capabilities. But, given the duration and budget of the project, a capital investment program was initiated and these facilities were developed.

We determined that a post-production audio suite was necessary to mix COSMOS or else we would have to go "outside". What with scheduling large blocks of time and contingencies we would have had to take over an entire facility for five or six months, which was out of the question.

Thus, COSMOS provided the impetus for the station to do what we had always wanted to do: build an audio post-production facility.

Where to begin? Well, we knew what everybody else used, having worked on KCET productions such as *Visions,*

Continued on Page 1034

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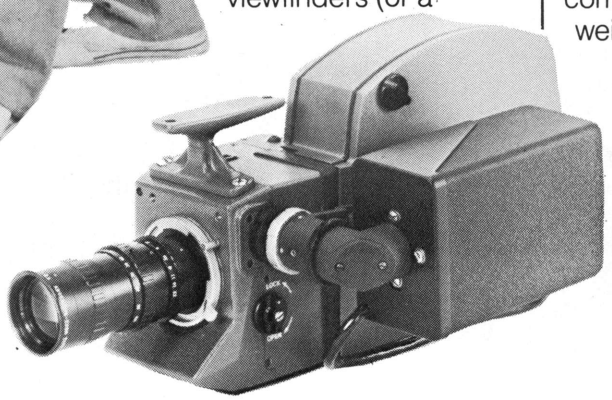

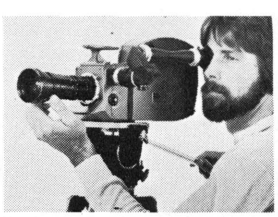

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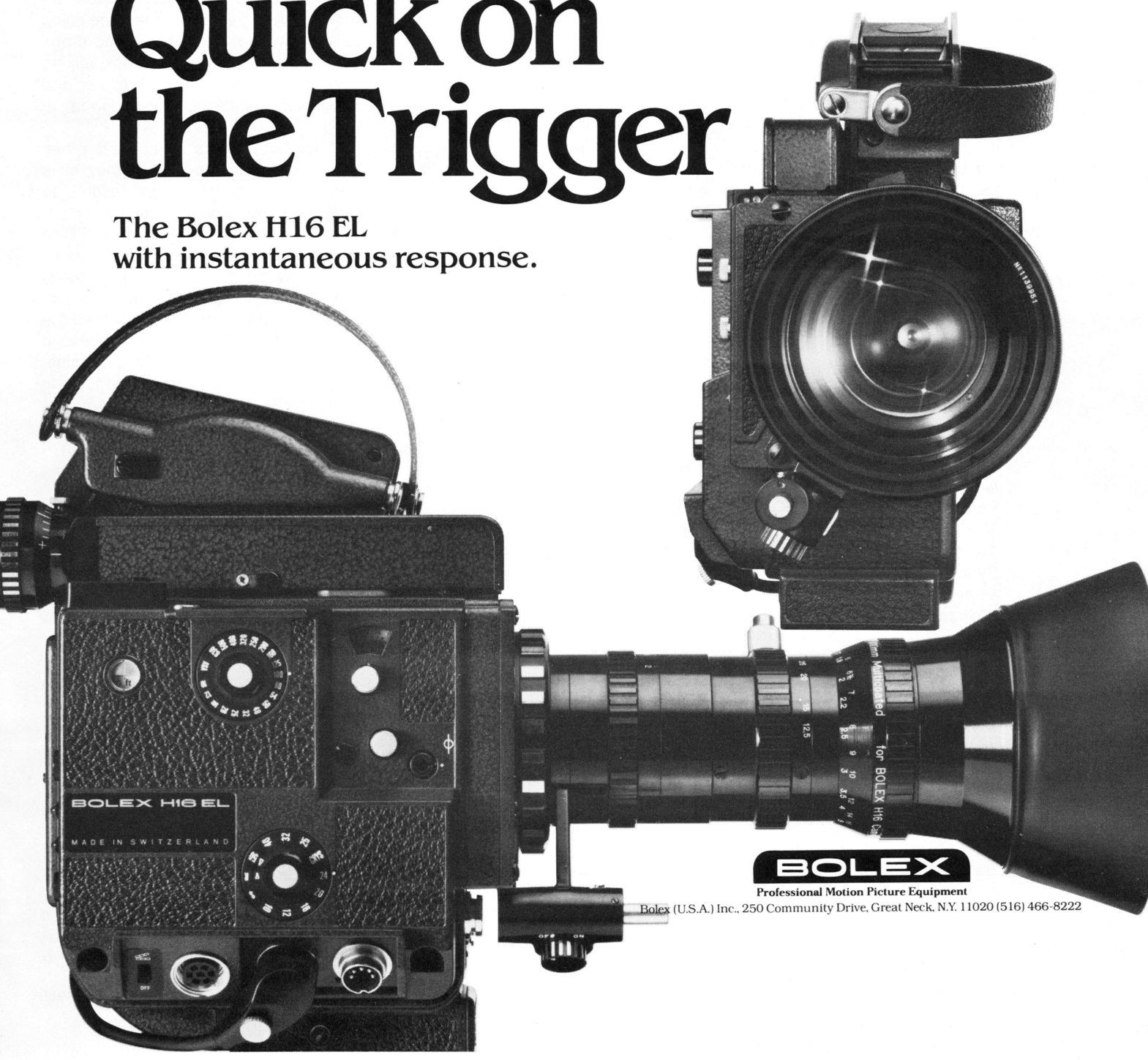

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"COSMOS" POST-PRODUCTION
Continued from Page 1031

Hollywood Television Theatre, concerts and opera, at Glen Glenn, Compact Video and Sunwest in Los Angeles. We had to decide what we needed to provide the maximum facilities without breaking the station's budget.

Many discussions were had with more questions and fewer answers developing each time.

It was decided that the station would enlarge an existing audio booth which already contained a console equipped for 24-track recording. But, beyond that we would have to buy everything new.

KCET engaged Westlake Audio of Los Angeles to design and construct the audio facility and to modify the existing Audiotronics console. An Ampex MM 1200 24 track recorder and 2 MCI ¼" audio tape recorders were purchased, as well as various pieces of ancillary equipment, such as an AKG BX 20 echo chamber, Orban parametric equalizers, UREI limiters, Bryston power amplifier and UREI time align loudspeakers. A Sony BVU 200 VCR was acquired to operate in sync with the 24 track and all of this was to be controlled by an Adams-Smith synchronizer.

When, in early May, we were to begin the first stages of mixing the first program we had not even checked out the brand-new system. Portions of it, like the Adams-Smith, and the BVU machine trickled in, somewhat late, as shows were already underway. I don't ever want to re-experience those first weeks! But it has all worked out and the system now works wonderfully well. It is efficient, flexible and produces a very clean soundtrack.

This is how we conceived that the audio elements would go together.

(1) Nagra ¼" sync, transfered to 16mm mag-edited to picture.
(2) Sync sound effects transfered to 16mm mag-edited to picture.
(3) Selected music tracks (requiring sync edits to pix) edited to picture.

As many as ten elements were assembled and what we called a "dirty" mix made for reference purposes. The picture and reference mix were transfered to 1" VTR to be assembled into the composite master of the program. The ten sound elements were also transfered discretely (track for track) to a 24-track audio recorder, along with 60hz sync pulse. This tape was then resolved and striped with SMPTE time code.

In the meantime, the master 1" VTR was being assembled with the various studio tape sources and already transfered location film elements (transfers being done at KCET, CFI, or most often, at Modern Film Video).

When the composite master VTR was completed the audio was laid over to another 24 track audio tape along with SMPTE time code.

At this time the film sound 24-track was synchronized with our composite master 24-track using the reference "dirty mix" as a guide, as well as checking visible lip sync. In addition, we used an old technique called "ESG" which is a voiced sync track, which, when placed on two pieces of tape gives a (voiced) reference to slew one tape playback into sync with the other.

Now, we had a 24-track tape with film sound, composite dialogue, a guide track and SMPTE time code which we could run in sync with a 3/4-inch cassette "workprint". And we had several tracks open to allow us to add more music and sound effects and also to mix our tracks down on the same tape.

All of these machines were synchronized using the Adams-Smith synchronizer. The people in Massachusetts delivered a device which synchronized our multi-track audio tape recorder and our videocassette player and any other devices we might like to patch in. It all might sound simple now, but only after a few scrunched tapes and many lost hairs did it all run smoothly.

After all the tracks are laid down on the 24-track tape we then go into what we call "mixdown mode".

Because COSMOS will be seen all over the world and will be dubbed into various languages we are mixing the program as if it were a feature film with dialogue, music and effects tracks and additionally what we call "music dipped" and "effects dipped" tracks.

We begin with the dialog tracks (VTR sync, film sync 1 & 2, and voice-over, as well as sync replacements). These various tracks are equalized and processed for balance and tonal quality and mixed onto one track.

We then mix the music and sound effects tracks simultaneously onto two tracks rolling back and punching in to make corrections. This process is fast and extremely flexible. We have two operators mixing the program with all machines being operated at the console using the Adams-Smith controls and a remote control for the BVU 200 cassette. We are able to shuttle back and forth to find the spot we want to correct, and can punch in on the fly or load in the time code number and have the machine go into record for us at the appropriate time. We can also load in a time code number to roll a given effect or music cue on cartridge or ¼-inch.

The 100% tracks are made for foreign versions where the dialog will be replaced. This allows the foreign producers the flexibility of balancing the effects and music to their dialog track.

After we have mixed the 100% tracks we then go back and remix the music and effects for the English version balancing these to the dialog track.

After this is completed the 24-track is laid back to the one-inch VTR and, thus, we have a completed composite master tape of the program.

A word on the audio quality of the final show masters: When the one-inch VTR machines were first talked about, their audio specifications were bandied about as if sound was being rediscovered. "Better than two-inch Quad VTR's for sure" BUT there is a trade off, we discovered. The one-inch machines do have a better frequency response but they hiss rather a lot too, and more than we could tolerate for the several generations we were going to have to go through in recording/editing, laying down on 24-track, mixing and laying back on the 1" master and duplicating for distribution. So what to do?

Dolby Labs, that's what! Maybe they could do for videotape what they have done for motion pictures and records. In fact, I knew they could do something, because for the past two years at KCET we have had two pairs of Dolby A type units on 2-2" Quad machine (Ampex 2000s) operating with a split head (stereo stack) for simulcasts. These had improved the sound of the 2" format in stereo beyond the monaural capabilities of the machine. So, to Dolby I went and to Ken Faye in particular. It seems that Dolby Labs was also aware of the 1" noise problem and were in the process of designing an A type unit for the RCA, Sony, and Ampex machines.

With some modification and great assistance from Dolby we have been assembling all 1" audio Dolby encoded and we lay back to the 1", Dolby encoded. The programs are much quieter than they would have been conventionally.

The COSMOS experience has been one of incredible learning, not only from the content of the programs, but also in developing what we think are new techniques in television sound production.

The sound on each episode is exhilarating to hear in the control room over our excellent sound system, but, as always, it is somewhat depressing to think about the viewer at home listening to our efforts over a five-inch speaker!

In the past we were always told, "Don't bother with the sound" . . . Well, that's true, but hopefully, not for long. If producers and directors and mixers put the

extra effort into the sound of the program, which we think, and hope, we have on COSMOS, *and* the audience realizes what they are missing, perhaps the set manufacturers will stand up and take notice. ■

"FILM" AS "TAPE" SOUND: NEW REFLECTIONS ON THE OLD BATTLE

by KENT GIBSON

Sound Designer

Sound (as well as visuals) have the distinction of being an intricate array of optimums balanced by real-life compromises in order to get out the best quality product affordable. On COSMOS, we tried to devise a system that suited us optimally, and I think we hit upon a system that filled our needs brilliantly and made use of the best that both film and videotape have to offer (see Gerald Zellinger's article).

Getting to the heart of the matter, let me identify several of my notions about the advantages of film versus videotape sound post-production: (NOTE: Optimums for COSMOS are not necessarily applicable to other situations.)

FILM—

Advantages

CODE SYNC—Visuals edited on film with corresponding coded mag tracks are a boon to the sound editor. Head and tail trims, matching ambience fills, and overlaps are easily located and accomplished.

MASTER CODED MUSIC—All of the music selections on COSMOS were transfered in duplicate with matching code numbers. This code match allows for replacement of "stepped on" work copy mag tracks with utmost ease. Extending of head and tail sections for music overlaps is also easily accomplished.

SPOT SOUND EFFECTS EDITING—Editing of spot sound effects where sync is crucial is done easier on film.

SCRAPING—Most sound editors will agree that one of the finesse attributes of editing on film is that it is easy to scrape out oxide on the mag to eliminate pops, and abrupt entrances and exits of sound. This is very difficult to do in videotape sweetening.

PHYSICAL MANIPULATION—There is nothing like actually handling film in an artistic formulation of sound track elements. Many editors and assistants find the lack of "feel" in videotape formats to be disconcerting for sound editing. It's true, it is easier to adjust a frame of film than a frame of videotape.

Disadvantages

MECHANICAL—Film is basically a mechanical and non-state-of-the-art process for organizing sound modulations.

TRIMS—There is an essentially "dirty" quality about having to keep track of sound trims. First of all, physical edits are always subject to being heard, except in the case of the perfect splice. Secondly, the process of track building is a time-consuming and mechanical process in these days of electronic accuracy.

TAPE—

Advantages

QUALITY VS. EASE VS. EXPENSE—The money quotient for tape sweetening is vastly different than for film. One has to balance an editor and assistant with film editing machinery for a certain time period, versus a sweetening studio at a vastly higher rate per hour. Some things are best accomplished on an editing bench and others are more efficiently accomplished in a sound studio. Clearly, tape is faster, but is not clearly as precise and of as high a quality.

CLEAN 'N EASY—Videotape sweetening affords a fast and easy method to build sound elements compared to film track editing. No worries with trims or tail sync marks. (Tape sweetening assumes time code interlock of a videotape element with a multi-track recorder, whereas film mixing assumes distributor interlock of film and soundtrack elements on dubbers in a mixing theatre.)

AMBIENCES VS. SPOT EFFECTS—In my view, it is easier to cut a gunshot on film and it is easier to lay a three minute section of outdoor ambience on videotape. Film affords the ease and accuracy to precisely edit in a gunshot—or twenty-five gunshots. Using endless loop carts in videotape sweetening, it is a piece of cake to effect a three-minute sequence involving four ambience loops. On film, one would have to worry about transfering enough of the effect to mag, then editing it into the necessary tracks.

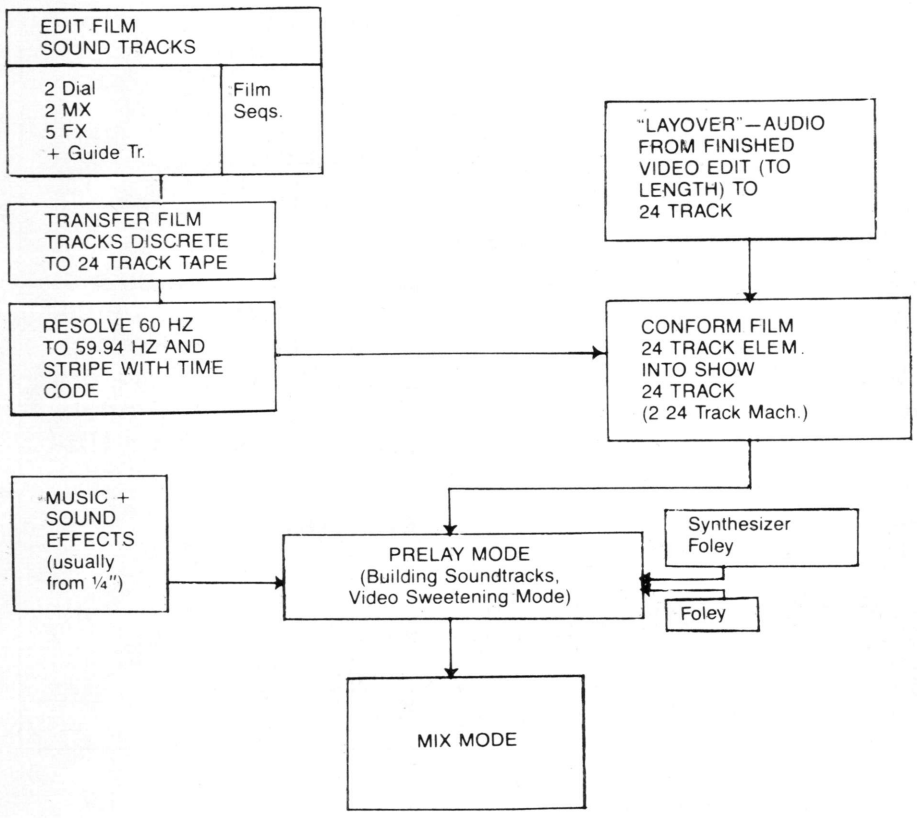
Disadvantages

LACK OF SYNC REFERENCE—Generally, laying in of effects or music in video sweetening is done with little help from any sync reference. Spot effects are laid in "on the lamb" and some degree of trial and error is involved. Depending on the video synchronizing system, music is placed by happenstance. Not to belittle many sweetening houses with very sophisticated computers, music "backed in" to a certain point is usually done by trial and error. Elaborate music editing on tape is very difficult.

EXPENSE—As a rule, an intricate sound editing job can be more efficiently accomplished on film and then laid in on tape.

ATMOSPHERE SOUND—As a rule, atmospheric sound elements can be more quickly and easily built on multi-track elements (sweetening). ■

FLOW CHART OF AUDIO POST-PRODUCTION ON "COSMOS"



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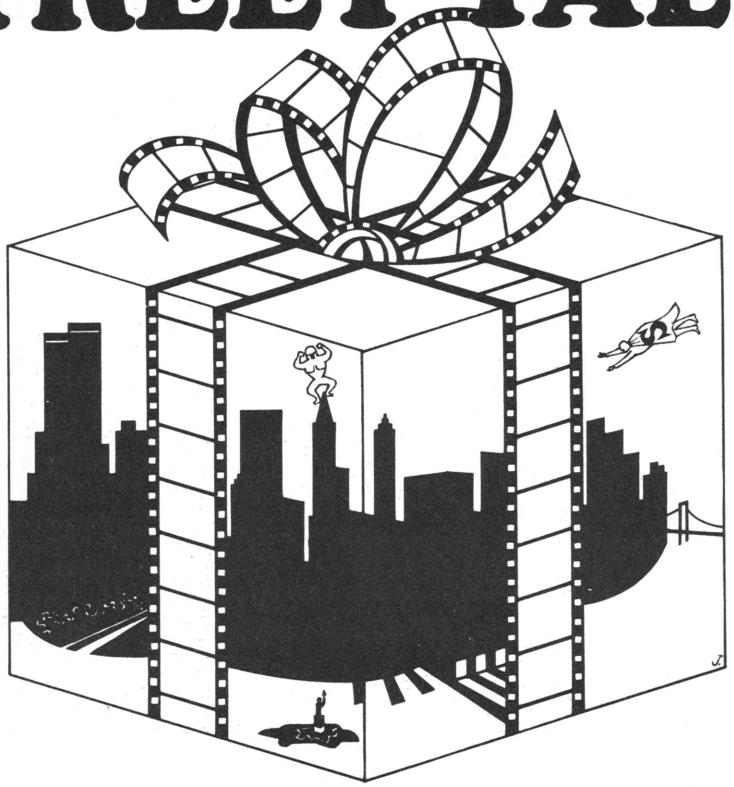

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Sol Negrin
John M. Nickolaus
Meredith M. Nicholson
Sven Nykvist
Emil Oster
Louis Page
J.F. Painter
Kenneth Peach
Harry Perry
Alex Phillips
Frank Phillips
Clifford Poland
Jack Priestley
Earl Rath
Richard L. Rawlings
Gayne Rescher
Jack L. Richards
Owen Roizman
Charles Rosher, Jr.
Harold Rosson
Giuseppe Rotunno
Joseph Ruttenberg
Robert Sable
Ted Saizis
Vincent Saizis
Howard Schwartz
James Seeley
Richard Shore
Lester Shorr
Clarence W.D. Slifer
Harkness Smith
Edward J. Snyder
William E. Snyder
Leonard J. South
William Spencer
Frank Stanley
Alan Stensvold
Clifford Stine
William J. Storz
Harry Stradling, Jr.
Karl Struss
Robert L. Surtees
Jack Swain
Ellis Thackery
Mario Tosi
Thomas E. Tutwiler
Frank Van der Veer
Zoli Vidor
Ted Voigtlander
Joseph Walker
Harry Walsh
John F. Warren
Harold E. Wellman
Frederick E. West
Joseph Westheimer
Albert Wetzel
Haskell Wexler
Charles F. Wheeler
Gordon Willis
Harry L. Wolf
Jack Woolf
Ralph Woolsey
Lothrop Worth
Vilmos Zsigmond
Frank C. Zuker

Associate Members

Mark Armistead
Volker Bahnemann
Bernard Barron
Emerson R. Barlow
Howard Bell
William A. Bickford
James Branch
Gerald D. Brodersen
Anthony D. Bruno
Claude Chevereau
Ronald Cogswell
Leonard F. Coleman
Michael Crane
Robert B. Creamer
Fred H. Detmers
Edmund M. Di Giulio
William W. Edwards
Walter G. Eggers
Tom Ellington
Blake Fendrich
Ted Fogelman
Milton Forman
Raymond Gaul
Richard B. Glickman
Dennis F. Godfrey
Robert Gottschalk
William Hansard
R. Bruce Hill
Harold Hinkle
Julian D. Hopkinson
G. Carleton Hunt
Fred Hynes
Masaru Jibiki
James Johnson
Robert E. Klees
John J. Kowalak
Robert Kreiman
Joseph R. Lee
Sol Lesser
Bern Levy
Herb A. Lightman
Grant Loucks
Lewis Mansfield
James F. Martin
Kenneth M. Mason
Stan Miller
Walter H. Mills
George Milton
George J. Mitchell
Bernard Newson
Meredith (Skip) Nicholson
Kemp Niver
Fred Nolting
Capt. Don Norwood
Otto Paoloni
Larry Parker
Warren Parker
John Pistor
Carl Porcello
Edward H. Reichard
John L. Robertson
Roderick T. Ryan
Loren Ryder
Dan Sandberg
Mel Sawelson
Fred J. Scobey
Peter Silverman
Burton Stone
Abbott Sydney
Harry Teitelbaum
Nat Tiffen
Richard Vetter
Lou Vincent
Frank Vogelsang
Jack Webb
E.M. Whiting, Jr.
Albert J. Whitlock
Ralph D. Whitmore, Jr.
Allan L. Williams
Michael Zois

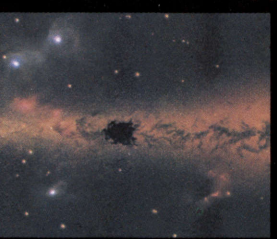
Honorary Members

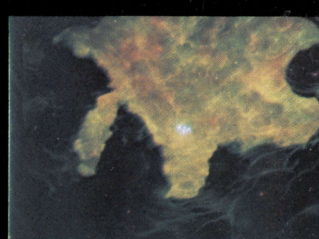
Col. Edwin E. Aldrin, Jr.
Dr. August Arnold
Neil A. Armstrong
Col. Michael Collins
Edward P. Curtis
David MacDonald
G.A. Mitchell
Sidney P. Solow
Richard F. Walsh



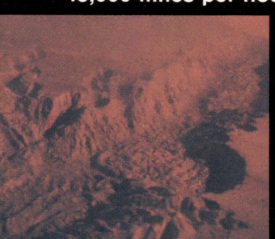
(LEFT) Chief Artist Jon Lomberg and Special Effects Supervisor and artist John Allison discuss the design and production of a multi-plane shot. The COSMOS Artists painted more than 4,000 acetate cells. (CENTER) Design frame, based on optical and radio data, of the Milky Way Galaxy, by Jon Lomberg. Our sun, two-thirds out from the galaxy core, is but one of some four hundred billion suns or stars. There are at least a hundred billion galaxies in the universe. (RIGHT) COSMOS artist Don Davis inspects an early hemisphere model of Titan, a moon of Saturn. (BELOW LEFT) Giant elliptical galaxy and quasar—somewhere near the "edge" of the universe. (RIGHT) The Cosmic Zoom approaches a spiral arm where our solar system and Earth are located.

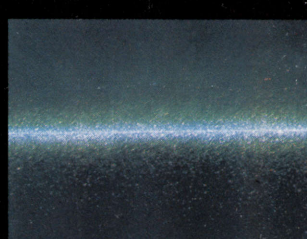

(A) A vast interstellar dust cloud is silhouetted against the plane of the Milky Way Galaxy. "I want space to be dirty," insisted Executive Producer Adrian Malone. (B) We plunge into the dust cloud to find a star inside it, hollowing out a cocoon for itself by its stellar wind pressure. (C) We approach the light-year-across Orion Nebula and plunge through its dust cloud. (D) Inside, new stars in the center are forming from this gas and dust. The many separate elements and their hold-out mattes were shot on a 40-foot track and an animation stand, and then the many pieces were combined optically.



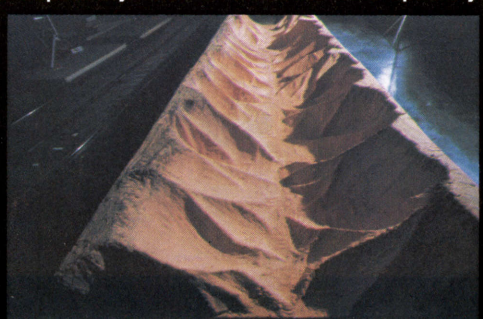
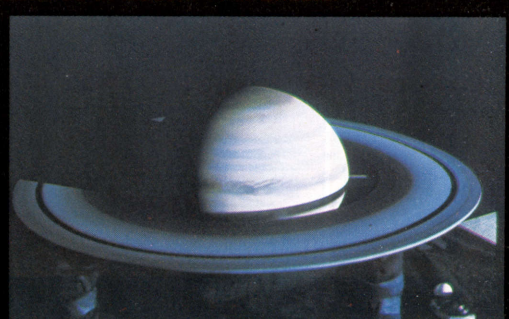



(A) Mars, the Red Planet. We descend to its surface and fly through Vallis Marineris, a giant rift canyon ten times larger than the Grand Canyon, with dust storms approaching half the speed of sound. (B) The Mars models were based on orbital pictures from the Viking mission. Oil-based fog was used to simulate the violent dust storms. (C) A descent to the surface of Venus was twice redesigned, as Russian Venera and American Pioneer spacecraft provided new information on the Venusian atmosphere (incessant lightning) and its surface (hell-like). (D) We enter the rings of Saturn from below the ring plane. Actually snowballs, these tiny moons whirl around Saturn at 45,000 miles per hour.



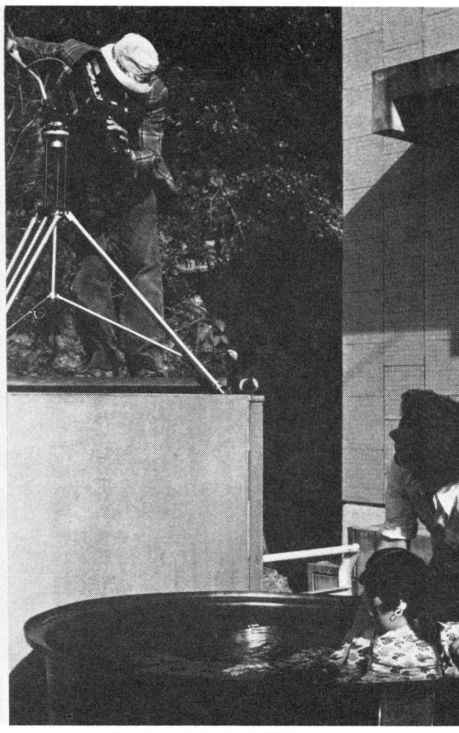



(LEFT) An imaginary planet with an advanced technological civilization network was dubbed "Marduk", after the Babylonian god. This was shot at Universal Hartland, with special thanks to Peter Anderson. (CENTER) A fast fly-through of the canyons on Mars was created with a 40-foot-long plaster, cloth, wood, sand and paint model. Tricky helicopter-like moves by Cinematographer H.J. Brown were done using the Kenworthy Snorkel Camera. (RIGHT) Artist Rick Sternbach built most of Saturn. The Saturn model was hung sideways to keep the rings from bending. A rear-lit star drum was shot separately. Then all elements were optically sandwiched at Modern Film Effects.

of the Angeles Forest had been burnt in the late summer and early autumn 1979 fires. We found an area which had been burnt over for miles around and in which there were standing the burnt remains of a few large trees, one of which still had a good number of brown needles. Back lit at dusk no one would know the difference, but we got only one shot at it.

The burnt area provided a striking location, but the two days spent there were hell on the crew and equipment. The ground was covered with a fine gritty ash which puffed up in little clouds at every footfall. It got into everything—all of the equipment, every pore of your skin, the food you ate and the water you drank. The Forest Service permissions were granted with a strict set of conditions, the most salient being that if the wind exceeded 15 mph we could light no fires. The first day of filming the wind was blowing in gusts up to 55 mph when we arrived on the location. It was spectacular; we could hardly get out of the trucks. Not only was the effects shooting out, but the sync dialogue sequences were impossible. Cameraman H. J. Brown and I ventured forth to see if we could do anything. H. J. is undauntable. We got the camera out and got some very good scenics with blowing ash and charred trees. It is truly otherworldly. With the weather predicted to continue blowing we decided to try to save some of the day by having Carl do some walk-throughs which we could later use to go with voice-over. By late afternoon the wind had diminished to 25-35 mph and we found a good location on the lee side of a hill to do some sync pieces. Working on a tight schedule with a small budget keeps you shooting long after the others would have gone home. You learn to make do.



(LEFT) On location in Czechoslovakia, filming a sequence in the life of 17th-century German astronomer Johannes Kepler. (RIGHT) Cameraman Christopher Fryman and Producer David Kennard prepare to shoot the drowning of the boy emperor, Antoku, for the Samurai battle sequence filmed in Shimonoseki, Japan.

The weather improved for the second day of shooting and we were able to complete the dialogue sequences as well as the special effects. Being able to talk about the disasters that can visit a world in a location which has itself been ravaged lends a lot of credibility to what is being said. This location powerfully reinforced the concept of the sequence.

To Ride on A Beam Of Light

Episode 8 of *COSMOS* is about space and time. No discussion of those subjects is complete without including the theory of relativity. Albert Einstein used to conduct what he called "thought experiments". One such experiment was to try and imagine what it would be like to ride on a beam of light. To illustrate Einstein's theory and the effects of travelling at near the speed of light we went to Italy. As a teenage boy Einstein had walked Italy's light-dappled lanes and must have been inspired by its beauty as was another visionary thinker from an earlier time, Leonardo DaVinci. We chose Leonardo's home town as our location. DaVinci was able to theorize and plan and devise flying machines, but the technology for such machines was unavailable. By applying Einstein's theories we can plan and devise interstellar spacecraft, but the technology for their construction and operation is simply not available. We can, however, think about the speed of light and discover that at the speed of light some very curious things happen.

At relativistic speeds, among other things, time dilates and space contracts, one's perceptions of the world are changed. The observations which can be made further depend upon the frame of reference of the observer. The traveller sees one thing, the one left behind sees something quite different. Illustrating some of these principles presented quite a challenge.

To achieve the effects we wanted for this sequence we enlisted the services of Howard Preston of the D'XTRS. Howard is a physicist and optical wizard. He de-

On Czechoslovakian loation a portable window is used to simulate two locations. The COSMOS filmmakers received highly competent technical and creative assistance from Czechoslovakia's short film production unit, Kratky Film. Many valuable antique instruments were loaned by the Prague Technical Museum.

vised and built a retrofocus zoom lens which, when it was fitted with a fisheye Nikkor, gave us a field of view which varied from flat to a highly distorted 220-degree angle of acceptance. Location shooting with this lens combined with some very precise blue and red mattes gave us a highly scientific glimpse at relativistic travel from the viewpoint of the traveler. We see the Doppler phenomena of red shift and blue shift as well as distortions of space, as what is behind us wraps around us and what is ahead is compressed. For the point of view of the stationary observer we used a combination of techniques. For moving shots of our boy on his magic motor scooter, we used rotoscope to create the Doppler effect. To illustrate a phenomenon known as the Lorenz Contraction we used a series of specially treated stills, shot with an anamorphic lens on a still camera.

The endless meetings with the scientific advisors before shooting the sequences were exceeded only by the time spent in fine-tuning the opticals to make them work just right. As in all areas of the series, scientific accuracy was of paramount importance. ■

COSMOS IN CZECHOSLOVAKIA
by TOM WEIDLINGER

It was not unusual, during the planning stages of COSMOS to be confronted with scientific concepts that had little or no screen potential, yet were intrinsic to an episode. Sometimes difficult ideas were made comprehensible and interesting by complex computer animation sequences, other times by models, or created landscapes. Yet a third answer was to place ideas in their historic and dramatic context. Typical of this approach is the half-hour sequence in Episode 3 on the life of the 17th century German astronomer Johannes Kepler.

Kepler is known for his three laws of planetary motion which, unfortunately, taken by themselves, are singularly uncinematic. Nevertheless, they are significant because Kepler's discovery of them represents a scientific and historical threshold: Up until Kepler's time astronomy was a speculative science, the realm of mathematicians and astrological quacks alike, its progress threatened by religious intolerance. But with Kepler's three laws, cracks began to appear in the fabled "crystal spheres". It was this conflict, the conflict between superstitition and reason, between chaos and the search for celestial harmony that dominated not only Kepler's life but the era that he lived in. The cinematic solution then, was to put the three laws into their historical context.

Unlike conventional docu-drama film, the Kepler sequences had to be designed to work almost exclusively without benefit of dramatic dialogue so they could be accompanied with Carl's voice-over narration. Choosing specific events in Kepler's life in which the greater conflict between chaos and the scientific search for order could be symbolized, we let the camera tell the story. The effect, in scenes that ranged from Kepler's early childhood in a strict Lutheran seminary to a lavish feast in the castle of his rival, is that small details become very important. A glance, the gesture of a hand, even the smoke rising from a snuffed-out candle become significant statements in the absence of conventional dialogue.

Needless to say, the reliance on this kind of detail to carry a film sequence is risky: One can easily end up with a scene which is without tension or conflict and, therefore, boring. One way we avoided this was never to choose an emotionally neutral camera angle or composition. Since Kepler was always at odds with the society he lived in he was always shown lost in big spaces, or moving against (in conflict with) the movement of the camera or in big close-ups, in isolation from the rest of the world. Choice of locations, set-design, and art direction were also critical since, just as the lack of dramatic dialogue calls attention to details in action it also calls attention to the details of physical ambience.

Fortunately, by filming our main dramatic sequences in Czechoslovakia, we had an excellent choice of locations as well as highly competent technical and creative assistance from Czechoslovakia's short film production unit, Kratky Film. An example of the attention to detail that characterized the Czech contribution was the preparation of food for the feast scene previously mentioned. Every item was real food, researched for period authenticity, and made in triplicate since it would get consumed during takes. The feast, a week in preparation, included three whole suckling pigs, dozens of fowl, platters of fish in aspic, and numerous types of authentic breads, etc. In another scene in which Kepler is seen working on an astronomical model, props included brass instruments, compasses and straight edges, that were made by the same instrument maker that supplied Kepler's patron some 380 years ago. These antiques were loaned courtesy of the Prague Technical Museum and were always accompanied by two armed guards.

Besides props and art direction we also relied on Kratky Film for set design, wardrobe, make-up, electricians, translators, and a remarkable production manager, Jiri Jezek, who somehow managed to keep it all working smoothly on a tight schedule and come up with the right permissions at the right times.

Most crucial to the success of Kepler was Czech talent Jaromir Hanzlik, who is on the screen for 20 minutes as Johannes Kepler, never says a word, save once, yet carries the performance with complete credibility. Hanzlik, after each day's shooting, would return to Prague to play Hamlet before a full house.

We have come to call the kind of filmmaking that the Kepler sequence embodies "created documentary", as opposed to conventional docu-drama. It is a unique challenge because it relies heavily on the perfection of detail and nuance as opposed to plot. Thanks to the many people who helped COSMOS in Czechoslovakia, we felt the challenge was met. ■

(Left to right:) Producer David Kennard, Host Carl Sagan, Cameraman H.J. Brown, Key Grip and Gaffer Scott Spencer and Grip Ken Dyer work out shot details on location in Enkhuizen, Holland. Location filming took place on three continents over a period of 18 months.

(LEFT) Lady Nii and the boy emperor, Antoku, aboard the royal barge during filming of the 12th-century Samurai battle at Shimonoseki, Japan. (RIGHT) Host and co-author of the COSMOS series Carl Sagan examines the Viking Lander, which has just set down in Death Valley. The Lander was suspended from a 30-foot crane arm and CO_2 was pumped through its retro rockets to create realistic braking blasts.

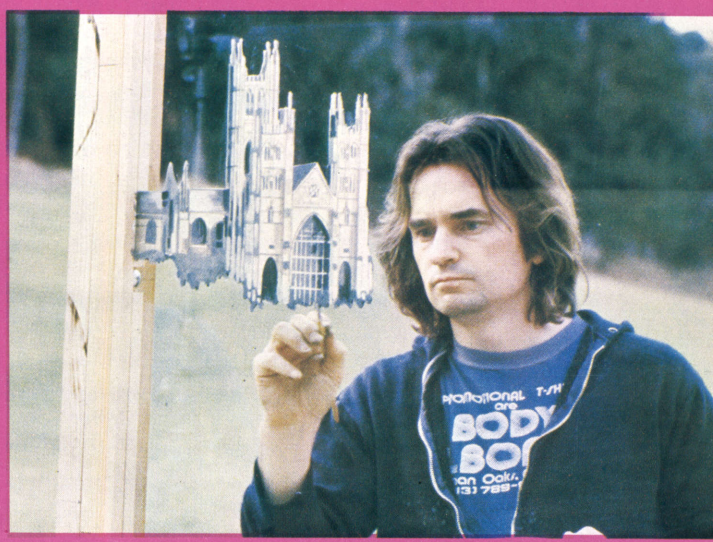
FOUR-IN-ONE FILMING
by RICHARD J. WELLS

COSMOS offered a rare directorial opportunity. Within the thirteen episodes there was a myriad of small stories to tell. Each required a different look. Some required using some of the earliest cinematic techniques. I had to make a little science-fact-fantasy, a Samurai film, a mini-costume feature, and a "B" horror movie.

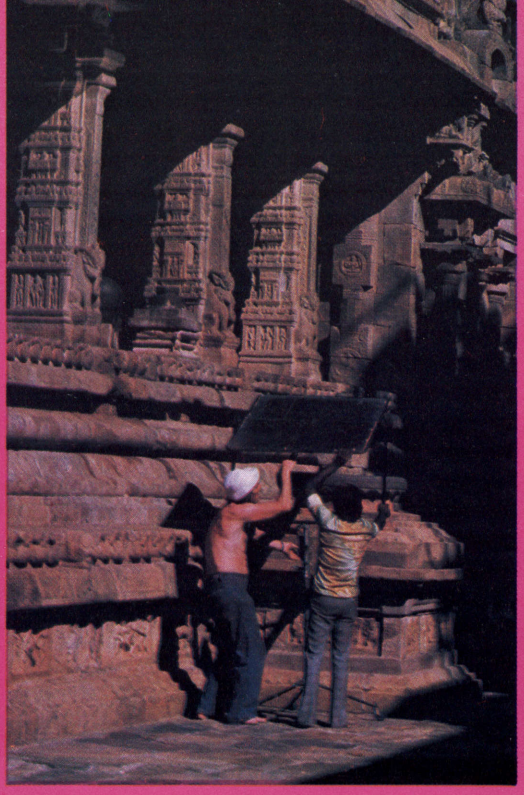
The science-fact-fantasy film was a recreation of the Viking Mission's Mars landing. I used an exact duplicate of the Viking Lander for the re-enactment. I wanted to fly the Viking in for a landing on an alien world. This film was to be a high-tech space adventure.

Suspending the Viking Lander from a 30-foot crane arm above Death Valley, we pumped CO_2 through the Lander's retro rockets to recreate the braking blasts executed by the Lander before it slammed onto the Martian surface. Shooting from radical low angles to avoid the supporting boom arm, cables, and the cage holding the CO_2 tanks, we low-

(LEFT) Working from the prop truck for protection from strong, chilling winds, British artist Ron King prepares the glass painting of two 17th-century Dutch East India merchant ships lying at anchor in the Rhodes of Enkhuizen harbor in Holland. Below: Dutch makeup artist C.J. Bannick, Grip Ken Dyer and Key Grip-Gaffer Scott Spencer discuss the upcoming shot. (RIGHT) Artist Tom Townsley puts finishing touches on glass painting of Canterbury Cathedral, with Griffith Park in the background.



(LEFT) Blond-wigged Dutch baritone Max Van Eground looks on, as Associate Producer Richard J. Wells and cameraman H.J. Brown prepare a shot in the sequence recreating a 17th-century Dutch *soirée* staged in Hofwijk, Holland. (RIGHT) The COSMOS crew works on a dramatic recreation for a sequence shot in the Netherlands. Almost two-thirds of the thirteen hours of COSMOS was filmed on 16mm film on location and this had to be smoothly blended with 35mm special effects and video footage.



(LEFT) Cinematographer H.J. Brown and Key Grip-Gaffer Scott Spencer work out dolly move in the Civic Hall of the Amsterdam Royal Palace. The COSMOS crew was the first foreign production unit permitted to film in the Dutch Palace. (CENTER) Gaffer/Grip Len Emory of the British film unit adjusts a reflector at Daresuram Temple in Tamil Nadu, South India for a sequence of Indian cosmology. A member of the native Indian crew assists. (RIGHT) An example of Czech attention to detail: Kepler's instruments.

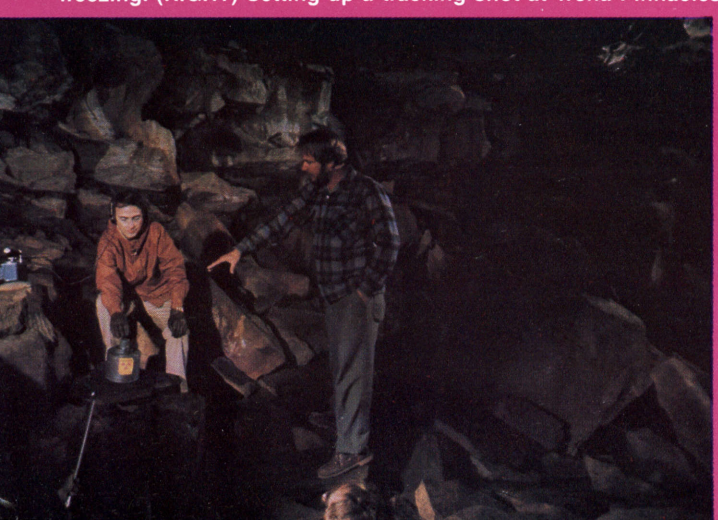
ered the Viking in gentle short drops until, with a final billowing thrust of gas, the Lander settled onto our pseudo-Martian surface.

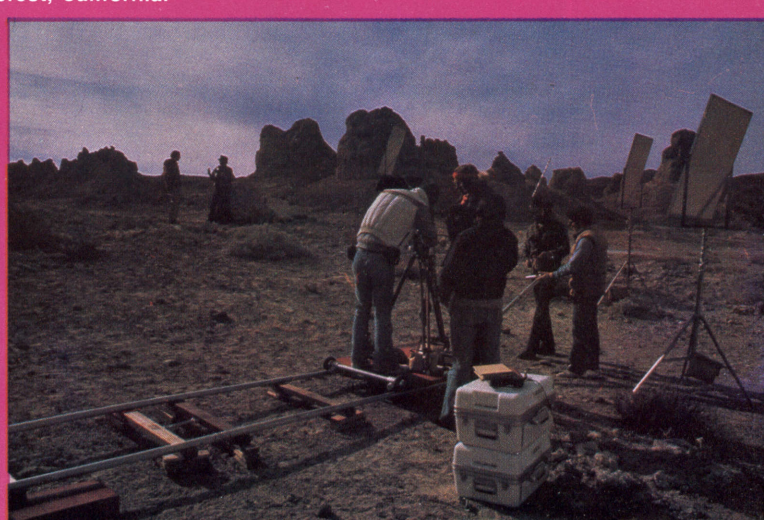
In the case of the 12th-century Samurai battle I filmed in Japan, the direct and simple imagery of the Japanese cinematic tradition served our story best. The sequence was designed as a moving Japanese painted screen featuring soft simple compositions. Each shot was an element unto itself. Yet, all the pieces fit together as a cohesive whole. A lot of mist, slightly diffused light to soften the image, and nearly two-dimensional "graphic" shots with minimum camera movement made the sequence Japanese in both content and context.

The mini-feature was a seventeenth century Dutch sailing sequence and *soirée.* We were able to get a feature feeling using dense, costumed crowd scenes accented by detailed sets. Together they gave the shots high production value. The scenes were rich with a variety of people and props. In addition, coverage was extensive. Interiors were rendered in muted rich colors, everything slightly diffused and bathed in an omnipresent warm fill light which appeared to be coming from candles or filtered sunlight. Lighting set-ups were extensive and time-consuming, but worth it, since it was careful lighting that gave the scenes

Continued on Page 1075

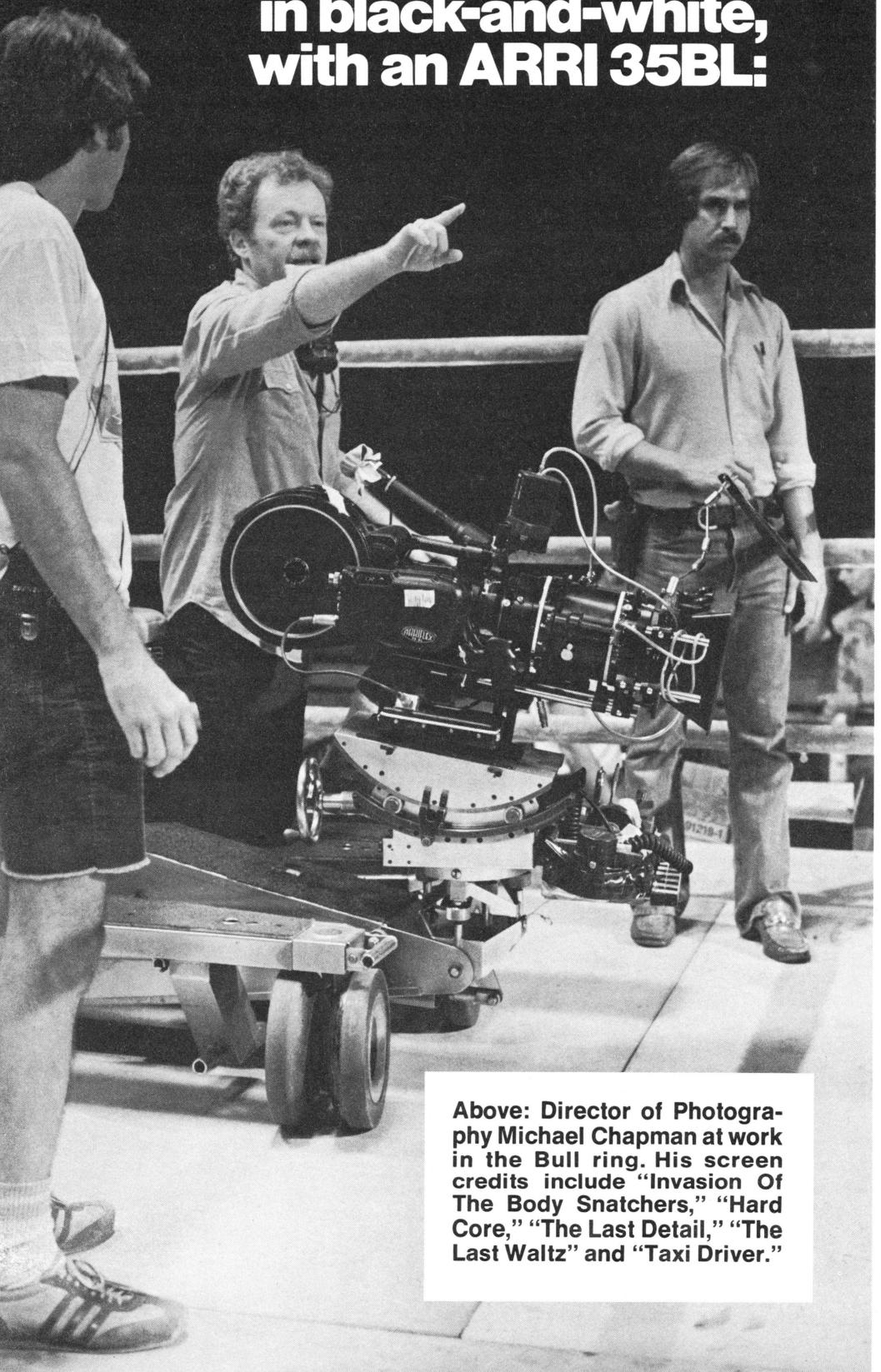
(LEFT) Associate Producer David Oyster (at right) directs Narrator Dr. Carl Sagan during filming in Government Cave outside Flagstaff, Arizona. The sequence called for cinematic depiction of the way cosmic rays penetrate through the earth effortlessly. The only place to demonstrate that was deep inside a cave with a Geiger counter (at left, beisde the lantern). The clicking of the counter indicated the presence of the rays. Although it was a sweltering day outside the mouth of the cave, the temperature deep inside the cave was below freezing. (RIGHT) Setting up a tracking shot at Trona Pinnacles, Ridgecrest, California.





"The fight sequences are choreographed as though it were a musical."

Michael Chapman talks about shooting The Raging Bull (directed by Martin Scorsese) in black-and-white, with an ARRI 35BL:



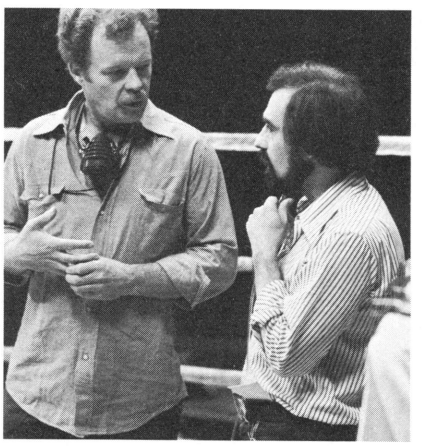
Above: Director of Photography Michael Chapman at work in the Bull ring. His screen credits include "Invasion Of The Body Snatchers," "Hard Core," "The Last Detail," "The Last Waltz" and "Taxi Driver."

It's about Jake LaMotta, a New York boxer who was Middleweight Champion in the Forties. *Raging Bull* is what the papers called him.

He's being played by Robert DeNiro, whose opponents in the film are all real boxers. Mr. LaMotta himself is acting as a technical adviser and has been on the set almost every day during the fight sequences.

Period stock

To add to the authenticity and period atmosphere, the film is being shot with Eastman Double X. "I had never used black-and-white before this job," says Michael Chapman. "I was apprehensive."

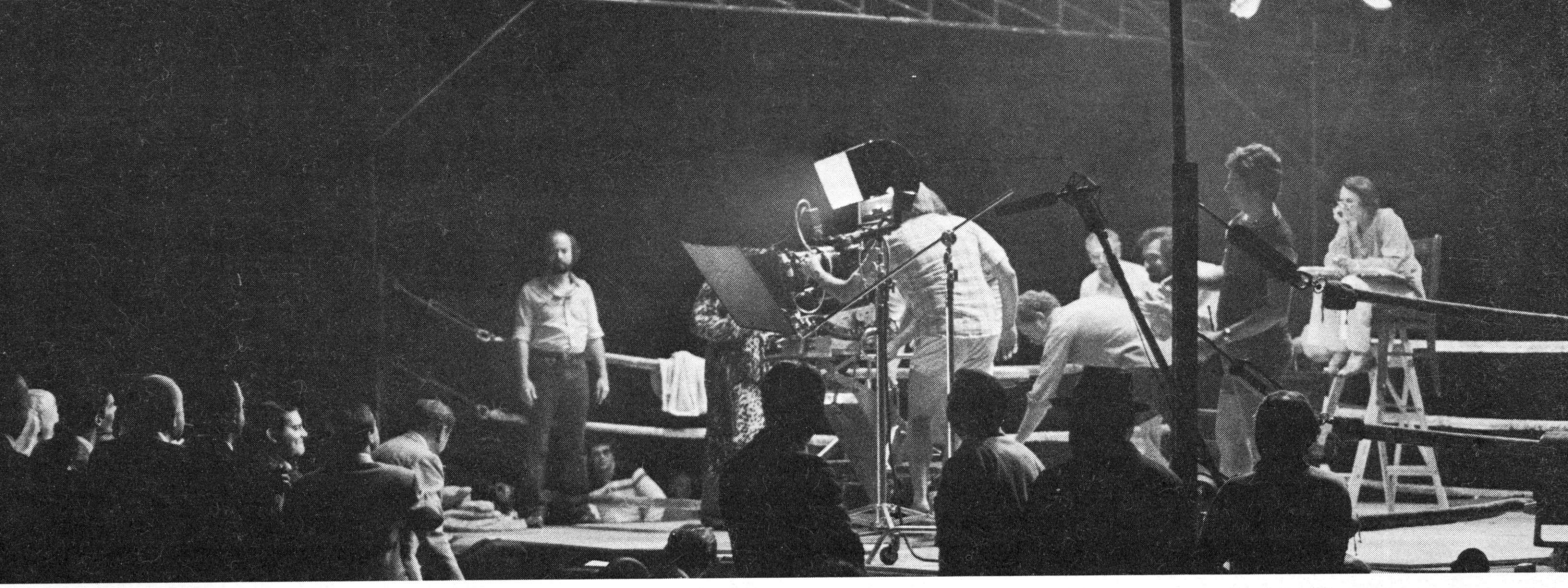


Director Martin Scorsese with DP Michael Chapman

"Before we started, I screened some black-and-white movies at MGM—*Double Indemnity*, *Salvatore Giuliano*. Even some Buster Keaton, because I remembered liking the simplicity. Separation *without* a rimlight."

Low ceilings

"We ran the usual tests; and I took a Polaroid onto the set with me, at first. I *still* think shooting black-and-white is more complicated. On some locations with low ceilings and nowhere to put the backlight, it can be difficult."



Shooting ringside spectators. Most fights are shot in real ring. Extra sets: rings that break apart, dividing ropes, one ring 40ft long (instead of 20ft), another that's not rectangular, for perspective distortion, *subjective* sense of what fighter experiences. 'Tobacco smoke' in the air is mineral oil, sprayed onto set for 8 weeks. Since it's a laxative, some of the crew wore masks.

"The choice of camera was mine," says Mr. Chapman. "I've been using the 35BL since *Taxi Driver*. For a realistic look on New York streets at night, we needed fast lenses."

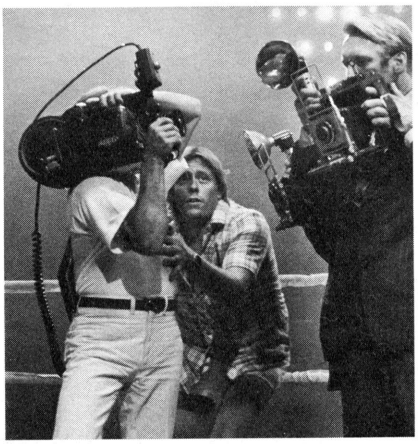
Accurate lenses

"After testing for *Taxi Driver*, we found the Zeiss set were the only accurate ones. The marked T1.4 *was* T1.4. Same thing stopped down. If it said T5.6 it was T5.6. They're superb lenses."

Feels good

"Two other things endear me to the 35BL: It's a marvellous camera to hand-hold. Sits right down low on your shoulder, balanced—like part of your body. *It feels good to use.*"

"The other thing I like is the 35BL's simplicity. It does everything I've ever needed—but the system is not intricate. And you can just grab three cases and go."



Operator Joe Marquette and 1st Asst. Dustin Blauvelt run around circle of "press photog." extras for downed boxer's groggy POV of ringside scene. 48 fps, with 16mm lens.

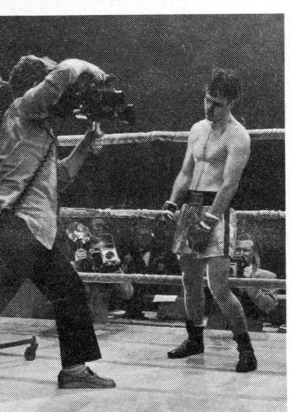
"The fights will be only about 20% of *Raging Bull*," says Mr. Chapman, "But they're the high points of the film—so we've spent about eight weeks shooting them."

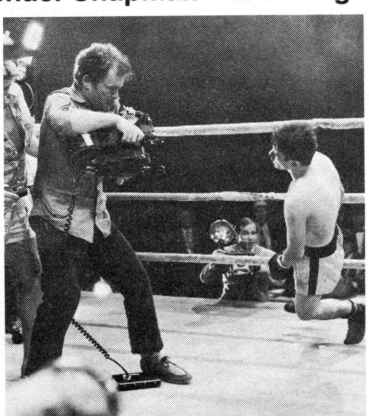
"Marty (Scorsese) likes a baroque shooting style. Lots of moves, elaborately staged. Different camera speeds. There's a storyboard frame for *every shot in every fight.*"

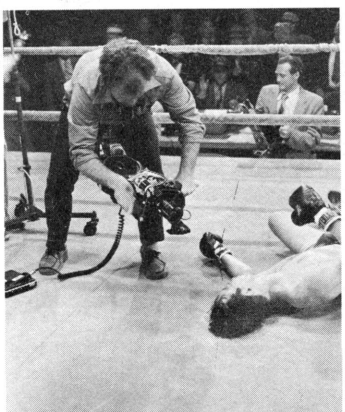
Baroque style

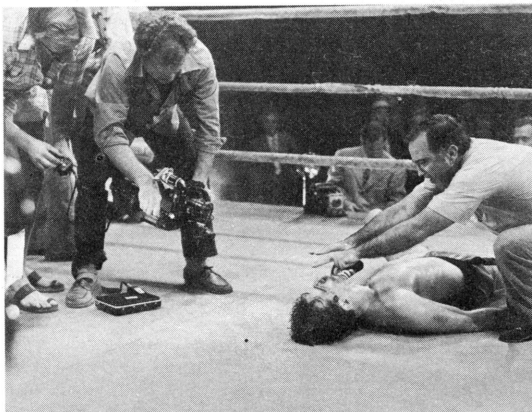
"Boxers constantly circle one another; and our camera never stops, either. 360° pans, crane shots...And every move—boxers *and* camera—is choreographed. Cut together, the fights all look like dances."

One of LaMotta's challengers (played by Kevin Mahon) gets knocked out. Michael Chapman hand-holds a 35BL running at 48 fps, 16mm lens. Closeup shots *inside* ring attempt to convey LaMotta's emotional POV, as opposed to newsreel or TV shot, spectator's POV outside ring.









DREAMING TO SCALE

Reproducing an area as vast as the Cosmos itself, plus the recreation of huge buildings long vanished, was accomplished by utilizing MAGICAM

By RICHARD J. WELLS

THE DREAM

COSMOS seemed a grand and audacious dream. The objective was to turn Pulitzer Prize-winning scientist Carl Sagan's story of the universe into a single, cohesive visual journey. Yet, it had to be entertaining, scientifically accurate, and visually innovative. It had to present the viewer with a new perspective of our vast and awesome universe.

Turning that dream into a reality meant going to the frontier of television's technology. Everyone involved in the project knew that producing 13 hours of programming featuring never-before-done special effects would be a production prizefight. But everyone was excited about the opportunity to turn cosmic fantasies into real pictures and to contribute to a fuller understanding of the cosmos.

In the beginning, Produce Adrian Malone established the premise from which we were to build the Cosmos dream. Budget considerations were not to hobble imagination, he told us. Armed with this mandate, the total staff, production assistants to producers, spent six weeks sitting like knights drawn up around conference tables, dreaming and strategizing.

Early production meetings were sparked with enthusiasm and great expectations. Pictures began to emerge to match concepts, sequences came together, and finally the 13 episodes took shape. We assembled and reassembled these elements until we had a set of visual and intellectual guidelines. These guidelines would prove to be both map and journey.

During the planning process, as agreement was reached on the content and style of each sequence, Malone assigned it to a director. My directing responsibilities ranged from shooting documentaries in Hawaii and Mexico to filming dramatic sequences in Holland and Japan. And although I was excited about my location sequences, I was thoroughly intrigued by the challenge of putting on tape or film the more abstract aspects of the cosmos—specifically, those awesome intangibles of time and space.

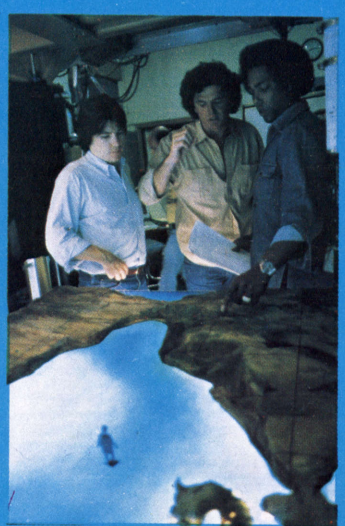
THE COSMIC CALENDAR

Central to Carl Sagan's story of the universe is the Cosmic Calendar. The calendar is Sagan's metaphor that reduces all of time, from the Big Bang birth of the universe down to this very moment, into one calendar year. According to Sagan's Cosmic Calendar, each month represents one and a quarter billion years, each day 40 million years, and each second stands for 500 years. The earth was born on September 14th. But all of man's recorded history occurs during the last ten seconds of the Cosmic Calendar year.

My problem was how to make this Cosmic Calendar photographable. Not only did I have to be able to photograph the whole calendar year, I had to be able to photograph individual months, days, minutes and seconds.

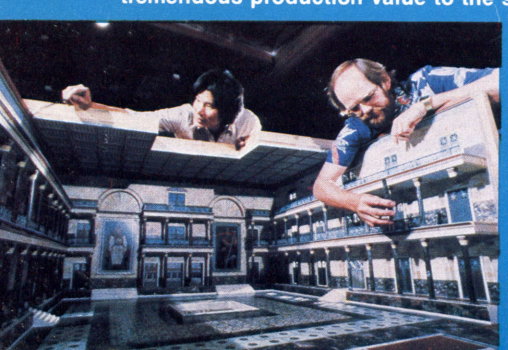
How big would a second be? That was where we started because the space that the last ten seconds would occupy would have to hold models representing the major material accomplishments of man such as the great pyramids, the Sistine Chapel and the Goldstone Radio Telescope.

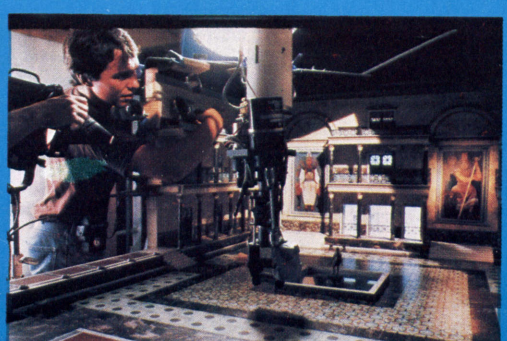
Originally, we thought we could solve our Cosmic Calendar scale problem on location. Malone and Sagan agreed that the calendar would work if its dimensions were 300 yards by 400 yards. The calendar would be a 25-acre set. All of man's

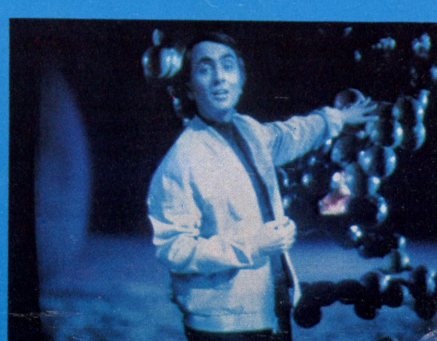


(LEFT) Presenter Carl Sagan and Director Richard J. Wells block out shot in the cerebral cortex set for brain sequence. (CENTER) The Cosmic Calendar basic graphic, without the 3-D effect. (RIGHT) From left to right: Special Effects Producer Greg Andorfer, Magicam President Joe Matza and Director Wells plot camera movement on the Cosmic Calendar.

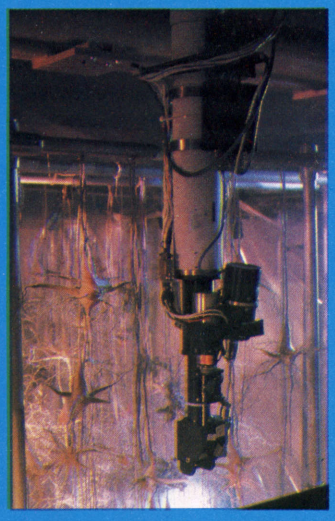
(LEFT) Model Builder Tom Pauk and model designer Jimmy Dow assemble main section of the Alexandrian Library. (CENTER) Gaffer Bobby Dickinson sets small mirrors used to control detail lighting on Alexandrian Library model. (RIGHT) Monitor showing composite picture of Carl Sagan explaining the DNA model on the Cosmic Calendar. The use of MAGICAM in the filming of COSMOS added tremendous production value to the series at low cost.







(LEFT) Model Maker Rick Thompson does touch-ups on the September section of the Cosmic Calendar. (CENTER) The Alexandrian library very precisely lighted for mood shot. This impeccably detailed model of the famous library destroyed millenia ago, looks absolutely like the full-size structure on the screen, especially when Carl Sagan walks through it, even crossing behind pillars. (RIGHT) Monitor showing composite picture of Carl Sagan in the Alexandrian Library.



(LEFT) The MAGICAM periscope camera flies by the neural network model. (CENTER) The crew and a stand-in on the MAGICAM Chroma-key blue stage. (RIGHT) Floor camera shooting Carl Sagan on the blue stage, with blue cutting piece for neural network section of the brain sequence. The camera on the blue stage is electronically linked to a slaved periscope camera operating in a miniature set and duplicating the main camera moves exactly.

recorded history would only occupy a five-inch by ten-inch strip on this calendar—a mere speck in cosmic time and a microspeck on a 25-acre set.

Using this scale, the earth model would have to be about twenty stories high. And while this sounds like a big problem, the biggest problem was where to lay out a flat 25-acre set with a clear line of sight from the lower right hand corner, the last 10 seconds of December 31st, to the upper left hand corner, January 1st, where we would stage the Big Bang. There were other considerations. Where could we count on having perfect weather for two weeks of exterior shooting? And where could we bulldoze eighteen miles of grid lines that were necessary to mark out the months on the calendar. When the eastern velt of Kenya emerged as our only solution, we changed our conception of scale.

A set 300-feet by 400-feet seemed manageable. All we needed was a flat area the size of three football fields laying side by side. We rejected an abandoned Nike missile base, stretches of unfinished freeway, the abandoned WWII internment camp, Manzanar, and finally the Air Force base at Wendover, Utah. Weather and logistics conspired to make them impractical. It was then we knew we had to find a special effects solution to our problem of scale.

MAGICAM

As part of the research for Cosmos, Greg Andorfer, the producer in charge of special effects, had talked to every special expert or team he could find and investigated all possible resources for making the Cosmos dream come true. Andorfer suggested that Magicam, already at work on a model of the Alexandrian library, might help solve our Cosmic Calendar scale problem.

Magicam is a visual effects company that has offices and occupies a complete sound stage on the Paramount lot. A separate design and model facility is a few blocks away. The magic in Magicam is pure space age technology. Two cameras are linked through a computer. Using a video camera on a background set and a second camera on a blue stage to shoot the subject and then compositing the two images through a switcher was not a new technique. What was new was that Magicam's principal camera is mounted on a Sidewinder Dolly on a vast sound stage. The camera dolly is equipped with a system of sensors which are connected to the wheels, the crane arm and the camera head. All of the movement sensed by these servo motors is translated through a computer to a periscope camera which duplicates any move made by the full size camera in a predetermined scale. This means that if you have a set scale of a half-inch to the foot, and the stage camera moves six feet, the periscope camera moves three inches. This allows for a full range of image sizes and camera movement. Subject and background remain in the correct perspective. Magicam is a versatile dual camera special effects system like none other in the world.

I was impressed from the first meeting with the Magicam team. Producer Carey Melcher, Technical Director John Gale, Creative Director Jim Dow and Director of Visual Effects Joe Matza were enthusiastic about the opportunity to stretch their system and create some special moments in the COSMOS series. Until then, Magicam had not been utilized for any major production efforts. But I was convinced that Magicam could solve all of our scale problems.

With Magicam we could have the complete illusion. We could achieve a quality matte without the tattle-tale blue around the figures. Magicam offered a sophisticated system, good engineering, and video control of the highest caliber. Magicam had all the right stuff. But the only way we could justify spending $15,000 a day for special effects was for the system to solve all of our unsolved scale problems and spread the cost over many sequences and screen minutes.

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I had spent about three weeks together knocking out the intellectual content and then I came here after another couple of months, having digested the material, and dictated the treatment, about 350 pages. I work like that. I work in vast spurts. I have to sit and think and then suddenly it all blurts out. And so I had about five or six people in a large room with a blackboard who were taking notes regarding various programs and I was sort of spewing out the visuals and the locations as they came to me, sometimes down to the shot, sometimes a vague description of the sequence that I could sort of vaguely see and they were giving me back things. Then, in another room, I had a costing team and so we did a 16-day massive bash of sort of 14-hour days, at which time one had this basic shape, but it was very amorphous and awkward, and then we fined it down and fined it down.

QUESTION: How did you arrive at the concept of a stylized spaceship as a device for telling the COSMOS story?

MALONE: As far as the effects went and/or the studio, I wanted to have a "spaceship of the mind". I knew that we could invent it somehow, but I also knew that I'd have to reduce all of the light levels in order to get the delicacy out of an electronic studio which you just can't get normally. So I said to the engineers, "You've got to take everything down to 30 footcandles. I don't know how you'll do it, but do it." They all shook heads and wandered away, but they all did it in the end. I said, "We need cameras that will go down to five or six footcandles. I've got to be able to work everything from that screen. The screen has got to be the brightest thing there, so everything has got to be below that, since that only transmits, at best, something between 10 and 20 footcandles. You've got problems. I want 15 footcandles to be shining like the light of day, so work it out."

QUESTION: Didn't it take the designing of a new projector in order to get the spaceship effects that you wanted?

MALONE: Yes. We had to invent the projector because the projector had to be rock-solid within half-an-inch at 50 feet, so that it didn't look as though we were projecting onto a screen. It really looked like space outside. Then I wanted lighting which would change as an object passed and, therefore, we had to have computers to come in. We rigged 350 lights and that computer program tied the lighting to the effects so that the whole thing was a closed system. So when a particular galaxy came up on our front projection screen the computer program on the lighting caught it and said, "This is galaxy so-and-so; therefore, the lighting should be so-and-so." Then, as that galaxy passed you, the lights changed along the skin of the ship. If you have a red star coming at you, you see it and you see the reflection of it going down the skin. That effect was achieved simply with theatrical lighting which was computerized.

QUESTION: Didn't the huge number of locations and effects to be achieved give you pause, considering the limited time and budget?

MALONE: The script called for about 40 locations, and the effects had to be done much more cheaply than one would normally do effects here. I didn't know much about effects when I first came here, but I learned rather quickly, because we did have a little problem with some of the effects. I wanted to try to push all of the technology beyond where it was. It seemed to me that this was important and not just for the sake of proving that it could be done, but because we wanted to do things which had to be beyond or just at the edge of the technology. For instance, we wanted to go down and see how DNA really worked. I don't just mean cell animation. I don't just mean little ball and stick models, but I mean to show the fact that there is a molecule which is a particular shape. It's a particular shape because it does a particular job. It moves in a certain way. The forces that it puts on a particular atom are such that the atom binds or separates from its adjacent atom. The objective was that people, if they saw this, would really see how the mechanisms of life work. They wouldn't just be given that sort of black box feeling. "Take my word for it, old chap, science knows how to do these things. So-and-so happens and then it produces this result." We didn't want that. I wanted people to be able to see that there is a real logic down there. It isn't just a piece of saintly garbage. It actually works and it works to engineering principles. Now, in order to do that we had to take some of the best computer people in the world, Jim Blinn and Charles Kolhase at JPL, and see if they could produce a program. They have and it's just a wonderful piece of animation. I think, for the first time, in all biological films, it actually shows you how DNA works, and it has an integrity to it. There is no mysticism to the thing.

QUESTION: I should imagine that, especially with a "mentor" as famous in scientific circles as Carl Sagan, the matter of scientific accuracy and authenticity would have assumed paramount importance for you in creating the effects for COSMOS. Isn't that so?

MALONE: I certainly did want the effects we achieved to have scientific accuracy, which is something that a STAR WARS or a STAR TREK doesn't have to have. That was a limitation in a way and, therefore, to achieve some of our effects we had to use many, many more elements that you would normally use, even in a major production like THE EMPIRE STRIKES BACK. There has to be a certain depth in a galaxy. It has to stretch over a certain number of light years. It has to be a very particular shape. Therefore, the constraints on us were much greater than if we had been doing a feature film.

QUESTION: What about the challenge of producing something on a cosmic scale that is to be shown exclusively within the relatively tiny confines of a television screen?

MALONE: I don't know whether you ever saw 2001:A SPACE ODYSSEY on television. But I mean, that film was a beautiful film—superb! Kubrick, I think, is an enormous artist, but his picture was diminished beyond all belief by being shown on a television, on that tiny screen. My medium for COSMOS was television and, therefore, I had to find a way whereby the audience, as a companion to Sagan, could "get inside the screen", where they wouldn't look at the screen as a window. That's essentially why the spaceship is there and why we're with Sagan, because then there is some sense of scale, some sense of the relationship of the size of the human being to the size of space. When you go full-screen on an effect, unless you've put it in a certain context, it just diminishes. So there were things one had to do for television, it being a closeup medium, that you wouldn't have had to do for a big screen. I would love to have done this for a big screen. That would have been terrific!

QUESTION: Getting back to the selection of your team, were you able to find people who already had all of the skills you required?

MALONE: The thing I had to do when I came here was to teach, because although there was a raw talent here—I

have a very talented team. Of that there is no doubt. I am very proud of having picked them—still, most of them didn't know this sort of television. They hadn't done this sort of research. They hadn't done "intellectual television", if you like. It sounds an awfully pompous phrase, but I can't think of another one—and they hadn't done it in the way that I had pioneered it. There is a certain way of doing these things, so I had to teach on the job. I love doing that, but it did put an extra strain on me—and also on the team, because they were learning on the job. There was no time for a sort of film course or a course in Renaissance history. One had to just do it on the job.

QUESTION: Once you had selected and instructed your team, what was the next order of business?

MALONE: The second stage of this thing was the making of the plan and that was a very rigorous exercise. That was systems analysis at its finest, because you were often dealing with three crews in the field, and with Sagan crossing between crews and with effects coming together all at the right time within the studio, it was about the equivalent, I would think, of between three and five major features all shooting at the same time, just in planning terms. It may be a smaller product, but the fact is that you are doing something which, in one episode, may include visiting four centuries. You may be going to five locations and you may be telling eight little stories all linked. You've got to put as much effort into any one of those little stories—even though they are three minutes long, or 30 minutes long, or five minutes long—as you would almost into a major feature, because the elements have got to be there: the actors, the costumes, the thought, the script. So you are putting a lot of effort into a fairly small jewel and then you are stringing the jewels together on a string, which means that the logistics involved in it and the planning are much bigger than the product seems on the screen. I think you can only do this if you do it on a critical path. There is a certain date when you cut off and say, "Imagination stops here, fellows. From now on it is a military exercise." Then imagination takes over again when you are on location, but in a cosmetic way. You've already set your plan. In editing it takes over again, but there is a point when it is just a military exercise and everybody has to realize this. If it doesn't go like a military exercise, then it doesn't happen at all—and that I also enjoy. I would love to have been a general, the only trouble with generals is that they have to kill people in the end. That's just one of those things that disqualifies me from wanting to be a general. Otherwise, it would be nice to be a general.

QUESTION: What factors were of special interest to you in accepting the COSMOS assignment?

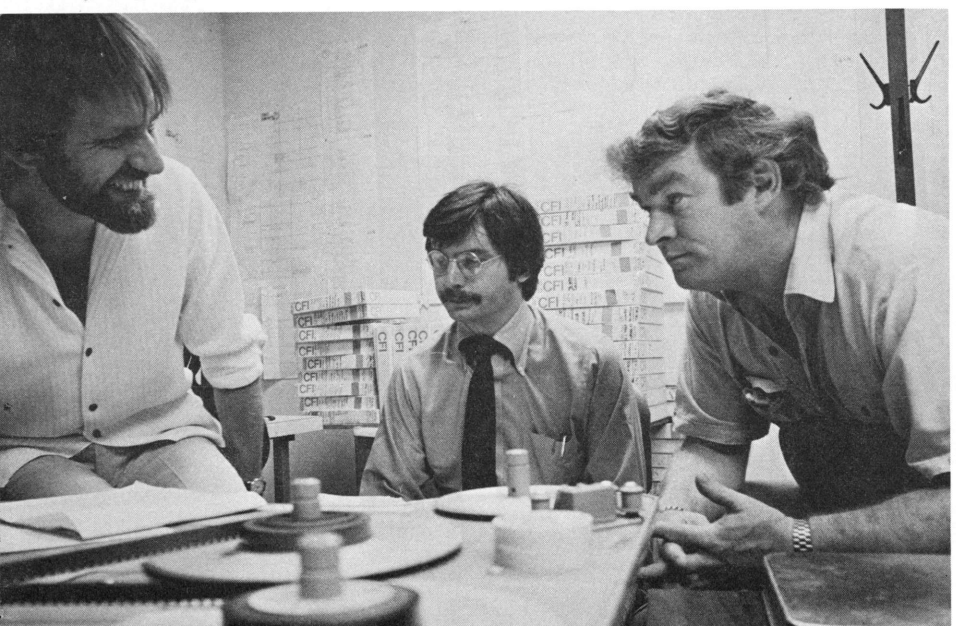
MALONE: The most interesting thing for me was to come from A) Britain and B) from the BBC to a very small organization. The literary tradition in British television is much stronger than it is here, so that was the major difference. The BBC was also like being a sort of member of the Roman Catholic Church, and I mean a monk; I don't mean a layman. Once you leave the great iron doors of that organization you feel rather small and cold and inconsequential because you've had the backing of this monster organization of 27,000 people with a department to do everything. There is a department to handle everything in the BBC. I left a legal wrangle going on at the BBC over a program of mine between the Vatican and the BBC legal department concerning a matter of theology. I don't know any other organization in the world that would have people who could actually deal in legal theology with the church. Well, when I left and came here I sort of cast about for all this support. Where was it? Why couldn't I ring up the controller of Foreign Relations and say, "I'm having trouble with the Greek Army in Samos. Could you get on to General Staff Greek Headquarters and talk to General Whatever-his-name-is and I'm sure he will talk to Brigadier So-and-so and sort it out? Fine." No, it wasn't like that. I had to do it myself. So I came to a fairly small PBS station to do this monster thing, which I think is probably the biggest of its kind, this series. And we had to just invent all the systems ourselves, because they weren't here. We had to have our own finance department, our own copyright department, our own research department. I had to suddenly delve back and try to build in microcosm a whole infrastructure which I had normally taken for granted. And that was interesting, but it was a bit frightening at first. On my bad days, I've said, when I'm really depressed, that it's like building the Titanic in the local marina—but that's only on the bad days. But once this thing is going, it's like a great monolith, a behemoth; it just moves along of its own weight and inertia and you have the feeling that every time you put in what to you is a fairly small plate on the hull, you crush five small boats in the doing. Because it's like this great pyramid upended; its base is small and there is this monster teetering about on top of it.

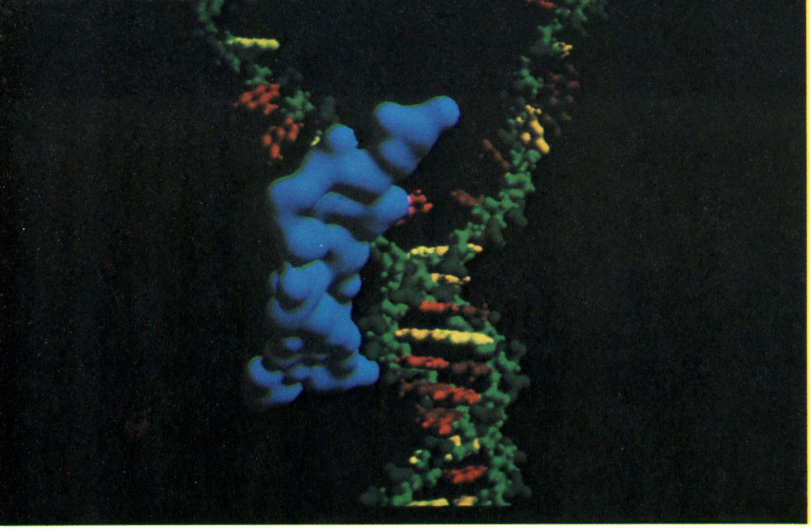
QUESTION: But didn't you feel there were some compensations in doing a project like COSMOS at a fairly small PBS station?

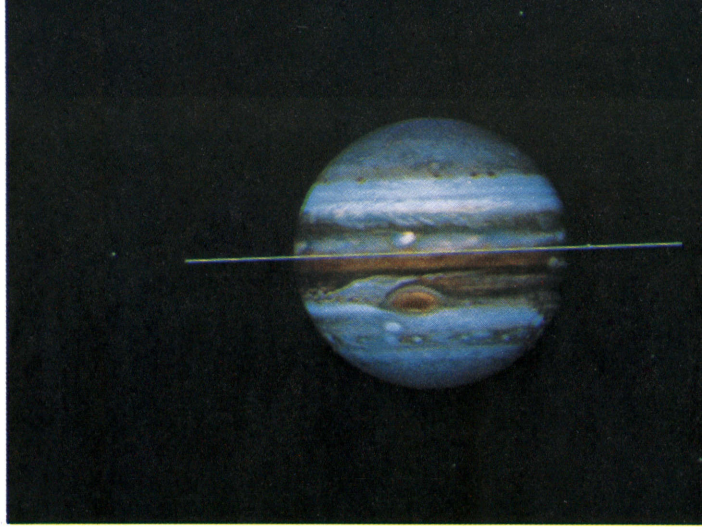
MALONE: Oh, absolutely! The tradeoffs were immense. It meant that I could so some things much more quickly than I could have done them at the BBC. I could control a lot of things myself entirely, with the staff, and we could invent our own systems and nobody could say yes or no because there was nobody to say yes or no. So we were able to do things in a less red-tape way, in a less institutional manner. There were times when we could just move fast and critically. I find it's very easy to work here with unions. It's easy to work with people. They know quickly what you want to do and they do it. There is no fiddling about. If you've got the money and you want the job done, they will do it,

Continued on Page 1063

Senior Film Editor Jim Latham, Producer Geoffrey Haines-Stiles and Executive Producer Adrian Malone review a segment of Program 13 at Latham's Steenbeck console. During his two years on COSMOS, Malone rode herd on thousands of details through constant personal contact with the key technicians involved and is proud of the fact that he issued "only six written memoranda".





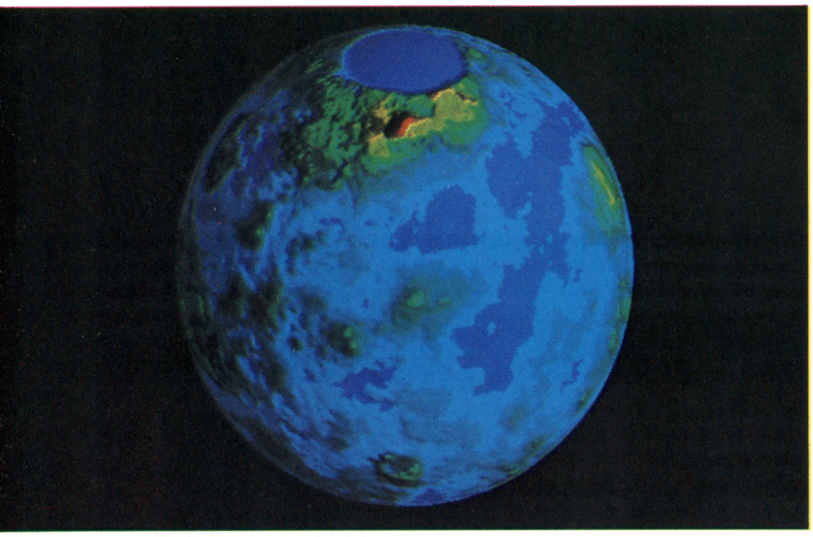


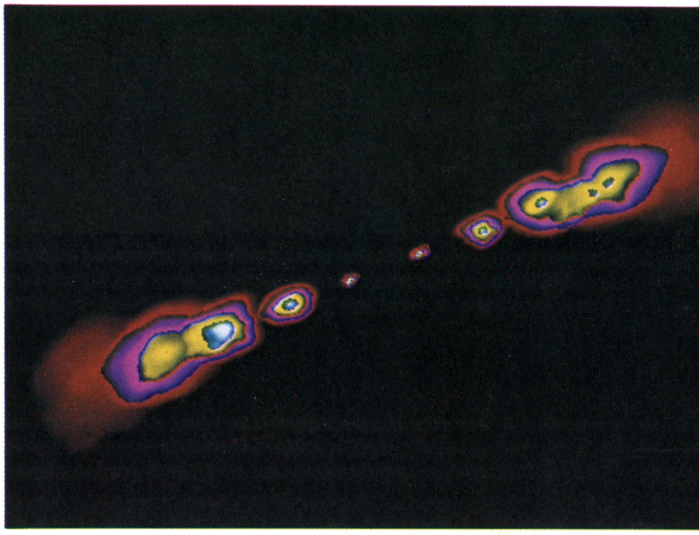
(LEFT) The DNA molecule is rendered in 3-D with polymerase (an enzyme active in the replication process) on the right and a free-flying nucleotide on the left. (RIGHT) Jupiter's newly discovered ring and the Great Red Spot appear in this view from Voyager 2 one day before encounter. The texture map for Jupiter's atmosphere was made by digitizing and blending actual Voyager pictures into the computer graphics data base.

COMPUTER MAGIC
Continued from Page 1019

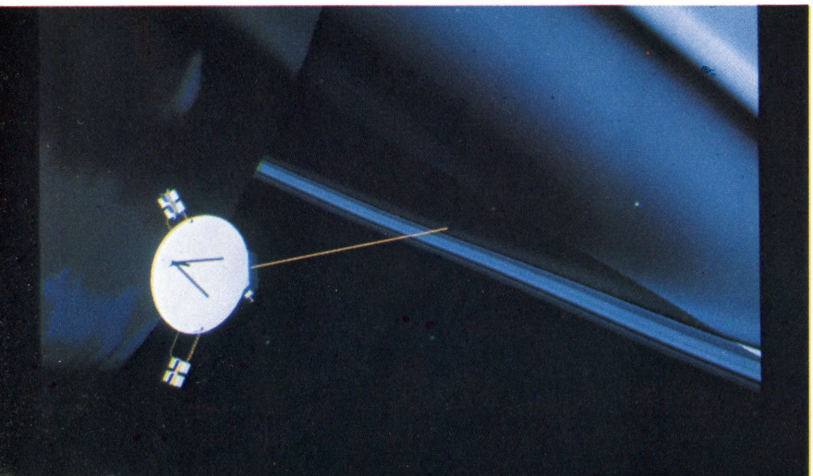
though mostly lines were drawn, we wanted to use color coding and to display the comets and planets more realistically. Making use of JPL software employed in designing Voyager and Galileo multiple gravity-assist trajectories, we designed a hypothetical comet orbit which had three close encounters with large planets to slow its speed within several decades. This is very unlikely to really happen; typically, it takes a few million years for a comet falling into the solar system to be captured as a short-period comet. Here, again, it was necessary to exaggerate science in order to make the intent of the sequence clear. Also, the rate of time flow was varied to compress slow events and to slow rapid events. The biggest challenge was to select the appropriate viewing angles and positions to follow the comet in history and to show the proper context of its position in the solar system. This required hours of human interaction using the vector system for rapid feedback prior to computing the final raster version.

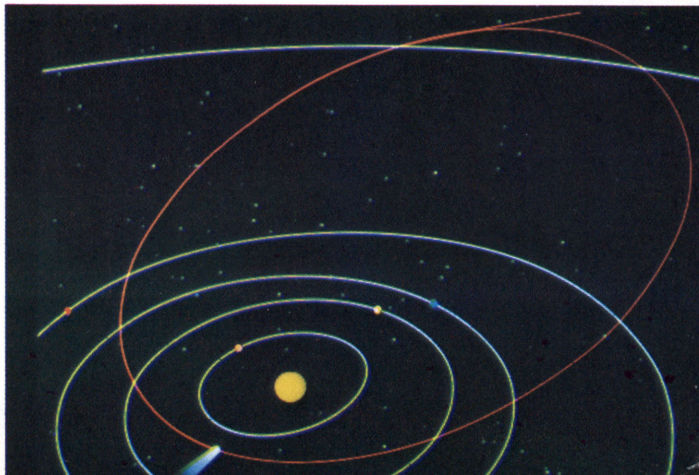
The power of computer simulation was well demonstrated in the course of producing a sequence concerning force laws. Scientists know that gravitational





(LEFT) Without its cloud cover, Venus is shown with surface relief and color-coded altitudes based on Pioneer radar altimeter data. (RIGHT) Pseudo-colored radio waves are emitted from a central point by an exploding radio galaxy. (BELOW LEFT) This exciting computer simulation of the Pioneer Saturn encounter shows the small craft below a whirling sea of ice and ice-coated particles shortly before closest approach with the giant planet. (RIGHT) A comet, having fallen into the solar system, is captured in a short-term orbit, with its tail pointing away from the sun.





force is derived from an inverse square force law. Initial information gathered by KCET and given to us at JPL indicated that no stable orbits could exist if this were not true. While we were producing an animation to illustrate this concept, the computer simulation showed some situations in which stable orbits could occur even under a different force law. The script was re-written to take this into account.

We simulated irregularly-shaped sources of radio wave emission radiating from a central point in a galaxy. Using a "digital paintbrush" type of computer program, we hand-painted the irregular shapes into computer memory using a digitizing tablet. Three shapes were used and transformed in two dimensions by rotating and scaling them as they emanated from a nucleus. Intensities from overlapping shapes were added numerically in the frame buffer. The final frames were displayed using a false color process which translated regions of different intensities into bands of different colors. We produced thirty seconds of animation by calculating five seconds of frames and filming them six times.

We also simulated the dynamics of a typical galaxy we modeled to be similar to our own. Thousands of random stars were generated based on a distribution provided by astronomers. Again, the vector graphics system was used. The stars were defined in three dimensions; therefore, the computer animation could view the galaxy from different directions. One part of the simulation represented the formation of spiral arms. Also, a path representative of our sun's path in and out of the spiral arms over billions of years was depicted.

One of the most visually realistic and detailed sequences used in COSMOS was a computer animation of the *Voyager 2* flyby of Jupiter. The *Voyager 2* trajectory film was made partly for KCET and partly for the JPL Voyager Project itself for the purpose of public information. This sequence reflects one purpose of the Computer Graphics Laboratory: to produce computer animations of space missions. Using software developed over one and one-half years, the motions of Jupiter, its moons, and the spacecraft were simulated. Using a vector graphics version of the software, a significant part of the actual production required hours of human interaction. Parameters were varied to defined key frames and to simulate camera locations that would optimize the views of the moon flybys.

To make the color, raster images for the final filming, maps of the surface features of Jupiter and its four Galilean moons were needed. They were created in digital form by processing pictures returned by the earlier *Voyager 1* spacecraft. For each frame, the computer calculates the latitude and longitude visible at each pixel and references the appropriate map, stored in computer memory, to obtain the color to display on the screen. The spacecraft is described as a collection of approximately 750 polygonal facets digitized from actual blueprints and shaded by the computer to look smooth and realistic. For the final computation of the movie, the main computer ran nearly 24 hours a day for 12 days.

Much of the space mission software was used to make sequences used in COSMOS. An animation of the *Pioneer 11* flyby of Saturn was made originally for the NASA Ames Research Center. Saturn's rings were simulated in three dimensions using a translucence pattern obtained from earth-based photometric measurements of the rings. Peter Blinn electronically "painted" an artistic conception of the surfaces of Saturn and its moon Titan into computer memory.

A fairly quick-and-dirty two-dimensional line-drawing animation system was programmed. In one sequence, human evolution is depicted, including major branches that led to other species. To accomplish the line-drawing animation, the computer software allows key frames to be traced and digitized into memory in such a way that individual lines are defined. Through human interaction with the computer, the lines between key frames are matched. The computer can then interpolate and store the in-between frames. Lines must be carefully drawn and matched in ways that provide for reasonable interpolation. For example, in human evolution, one leg of an animal might have been drawn as six or more separate lines. To handle limbs that come from behind bodies, a 2½-dimensional hidden-line-removal algorithm was implemented. As the project progressed, the software grew to automate procedures such as connecting and smoothing lines and positioning elements on the screen.

By far the most difficult computer animation produced for COSMOS was a three-dimensional, color simulation of DNA replication. This project required the largest number of new techniques concentrated in a short period of time. A new display algorithm was invented to draw molecular shapes so that atoms look melted together based on electron density surfaces. This is a more accurate way of depicting the actual appearance of molecules than is the traditional ball-and-stick model. The generation of each frame was driven by simulating the replication process using an accurate model of the position of each atom in the DNA molecule and the articulation as the molecule unwinds and replicates. The action of two enzymes was represented and since their exact shapes are unknown, nebulously shaped forms were modeled according to educated guesses. Free-flying nucleotides move randomly on the screen; however, some human interaction was involved to eliminate nucleotides that hid the DNA molecule at important points.

The computation time of each frame of the three-minute DNA sequence took much longer (up to one hour for certain frames) than that required for the other scenes. Therefore, we computed the frames on several machines in parallel. To be safe time-wise, we first generated enough frames at least to quadruple-frame the film and then filled in double frames for the entire film as time allowed. A massive merging of the frames was necessary before filming. Even in an encoded form, the frames filled fifteen digital magnetic tapes. The sequence was broken into three sections because the computer was not large enough to hold the data for the entire sequence at once. The data base was laboriously generated so that the last frame of one section matched the first frame of the next section even though computed differently. The pattern of the bases along the DNA helix was the actual correct sequence for the replication of hemoglobin. (This accuracy may be lost to the general veiwing public but was not ignored in the name of science!)

Finally, a sequence about Venus shows Venus rotating and represents its surface without its cloud cover. This was based on data returned from the Pioneer Venus Orbiter, an Ames Research Center project, using a radar altimeter. Altitude data were provided for each latitude and longitude. The frames were calculated to simulate surface relief as well as to color-code variations in altitude.

Computer graphics has established its place as an effective aid in producing special effects. Many scenes in the COSMOS series that used computer animation could not have been matched with conventional methods. As equipment and techniques become more sophisticated, computer graphics will play an increasing role in film and television production. ■

(ACKNOWLEDGEMENTS: Special recognition is due to David DiFrancesco of Lucasfilm, Ltd. [previously of JPL] for calibrating the Dunn box and providing general film and video expertise; to system programmer Eric Levy and computer graphicist Julian Gomez for their support; and to Glenn Zucman, JPL Computer Graphics Laboratory, for his assistance in photographing the illustrations for this article.)

DREAMING TO SCALE

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SCALE

Magicam's video matting effect easily solved our scale problems. With matting, we could put Carl Sagan in any background, including the Kenyan veldt, without ever leaving the security and control of the sound stage. If we wanted a six-foot Carl Sagan to share the stage with an 18-foot dinosaur, we established scale at one-half-inch-per-one-foot. That makes the dinosaur model a manageable nine inches. The Magicam computer takes over from there. It scales everything to that half-inch-to-one-foot standard. Then it makes all camera moves and secondary images, like background rocks and trees or objects on the set with Carl, in proper scale. With the slave set up between the two cameras, the composite picture will show all camera movement to be exactly the same on Carl Sagan and the dinosaur. Likewise, we could create a Cosmic Calendar 300 by 400 feet and execute it in scale.

EXECUTION

The Cosmic Calendar set was done in sections with one "aerial" view to establish the three-by-four rows of months, January through December, within each month, the appropriate cosmic event would be depicted through multiple special effects, light effects for the stars and galaxies, and three-dimensional models for the planets.

From the "aerial" view of the calendar, the events in each month would be visible. However, it was not possible to construct a single model where all effects could be shot in one pass, so Joe Matza, Jimmy Dow and John Gale devised a multipass method to achieve the effect, utilizing Magicam's newly patented programable motion control system. It was an industry first—a real-time motion control move made by the computer-controlled periscope camera. The move is programed in by actually panning and tilting the servo slave camera head on the computerized Sidewinder Dolly, using a video monitor as the viewfinder for the periscope camera. In this way, I was able to "fly" the "aerial" while the computer recorded the coordinates of the move. This hand move was then further smoothed out through the extra computer function that Magicam has developed. After we made an acceptable pass, the computer was able to duplicate the 52-second move in real time as often as necessary. Once the move was programed into the computer, we began to build up picture layers. First we laid down the basic graphic of the calendar page. On the next pass we put down the galaxies and stars that "float" above the surface of the calendar. On the third pass we put in all the third-dimensional elements; i.e., floating planets and the earth model.

Once we began to photograph the surface of the calendar, we broke the lower four months into forty-eight-inch, back-lit, plexiglass squares to serve as the settings for Carl's walk through the last four months of the Cosmic Calendar year.

Once we left the month scale of the universe, our conception of models had to change. We now had to depict in closeup more familiar scenes. For example, in the day scale, we had to show plants and animals. Though many of them were prehistoric, their size and texture were familiar to the television audience and crude three-dimensional models wouldn't be convincing. It would take time and money to make highly detailed models. We had neither.

We decided to take an impressionistic view of these elements and employ an old technique—painted flats and backdrops. There had to be nine separate settings to cover the last 11 days of the Cosmic Calendar year. The period in the earth's history from the earliest plant and animal forms to the first cities organized by prehistoric humans. These sets became tightly rendered paintings of plants and animals in background vistas with forced perspective and the tight renderings of the cut-out flats used as foreground objects contributed to the dimensional illusion of the set. With miniature set dressing of colored moss and rocks, the setting was not "real" in appearance but it was impressive in detail because of the magnitude of its size. In reality the widest vista was no more than 18 inches by 24 inches. But with a 3-inch Carl Sagan walking through them they took on a majestic grandeur.

Beside the Cosmic Calendar, there were several other sequences with major scale problems, including the Alexandrian Library and brain sequences. And each required a different solution. Magicam's flexibility made it possible to solve those problems and execute each sequence with high visual impact and intellectual integrity.

The Alexandrian Library was the optimum set for a director using the Magicam system. The library was an ancient repository of knowledge. It was destroyed two thousand years ago; yet we had to reconstruct it with archeological authenticity. Research revealed the library to be an enormous complex of buildings with hundreds of rooms, long-columned walkways, gardens, and fountains. It was three stories tall and completely covered with marble. But there were no ruins to establish the floor plan. The Alexandrian Library had to be built from scratch. It had to be perfect in every detail. It had to be shootable as a full set.

Working from the plans of KCET's Art Director, John Retsek, Jimmy Dow created a model of the library that satisfied all these requirements and was extraordinary in its detail. There were hand-painted column capitals, marble that looked real in closeup and three-dimensional objects like benches, vases, and statues that gave the set an added touch of reality. Director of Photography Steve Burum, lit the model with concern for mood and detail.

The Magicam system allowed me to shoot the model set exactly like a full-scale location. Dollies, pans, and sweeping crane moves seemed natural. Carl Sagan was able to walk behind the columns, upstairs, and through doors. The viewer gets a sense of reality. During one of the pickup shoots, a stagehand asked where the library was located. He said he'd like to go and see it. We achieved a high degree of realism by employing certain conventions that "sell" the model; that is, make it believable. These conventions included crossing behind columns, panning past real foreground objects, walking upstairs with shadow-breaking on steps and of having the principal interact with fill-sized props on the blue stage. All of these things you only expect to see if it's real.

In episode eleven, the script called for Sagan to take a walk through a human brain. He had to be able to stop at the neural network, where thoughts and memories become flashing electrical impulses sparking through a vast nerve system. He had to walk through the *Corpus Colosum,* a canyon-sized fissure that divides the two halves of the brain, and he had to stroll through some convolutions of the cerebral cortex where the convolution walls magically turn into a library lined with thousands of books representing all the accumulated memories and knowledge of not only a lifetime but all of the knowledge passed down through the genetic code of the human species.

Carl's stroll through the *Corpus Colusum* and the convolutions was achieved through a standard two-camera matte on the huge Magicam stage. Jimmy Dow created a multi purpose set of cerebral cortex convolutions. By simply laying these sections flat or standing them up in relation to a finely rendered, back-lit plexiglass painting of a section of a skull seen from within, we were able to see Carl in various sections of the brain as we "flew" about the convincing model with the periscope camera.

It was in the neural network that magic came into play. Working from scanning electron microscope pictures and artist's

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A VIEW FROM THE KITCHEN
Continued from Page 1027

quarter-mile long! Not having any friends at the Southern Pacific, we had to work out another technique.

Taking a still photograph of the planet model, we made a series of transparencies each one-sixth the size of the next: from 18 inches in diameter down to 1/12 inch. We began with the largest transparency and ran the camera up the column. Then we switched to the next smaller transparency, matching position, image size, color balance, effective exposure, and apparent velocity. Starting the camera back at the bottom of the column, we continued the zoom, repeating the procedure with the next transparency, and so on. (Then we did it all over again for the mattes.)

Galactic Diffusion: Imagine a race of beings leaving the home planet and colonizing other worlds, then multiplying and growing outwards, creating great channels of commerce throughout a sector of the galaxy. These channels branch out and extend toward every inhabitable star . . . . until they encounter another civilization. This is what we animated, a map of the growth of a hypothetical civilization on a galactic scale. At first the design of the scene was a la Rand-McNally road map, but eventually another image emerged. The entire civilization began to look like a biological organism. The "roads" looked more and more like branches and tendrils and fine root systems. This seemed right. The second civilization was distinguished not only by color but by different structure (less branchy, more filamentary) and a different style of growth. When the two civilizations encounter one another, they are shocked and flee and then settle down to peaceful coexistence. But while animating them (painting directly under the camera, trying to concentrate on dozens of root ends growing simultaneously) I grew so attached to these two ambitious little races that I couldn't help adding a fillip at the end of the shot (which was left on). After filling in all the accessible space, the two cultures return to face one another and intertwine their tendrils—giving birth to a third hybrid culture, with the branches of one group, the filaments of the other and the colors of both. This hybrid then shoots out to explore a whole new arm of the galaxy. ■

tripod because, although it is heavy and bulky, its choice of four different fluid settings on both Pan and Tilt movements, and its special suitability for use on dollys made it worth the extra effort involved in carrying it. It is also extremely reliable under adverse climatic conditions, and I had used this particular head under severely punishing circumstances many times before. Our electrician carried a set of four Ianiro "Redhead" quartz lamps which are very robust, with both 240V and 120V bubbles, plus 30V battery lamps and an enormous range of foreign plugs and adaptors. John Page carried two Nagra IV recorders with a very comprehensive range of microphones, plus two radio mikes. Literally kilos of batteries were taken, as experience had taught us that such common objects could be scarce and expensive in India and the Middle East.

The overnight flight was stuffy and the aircraft seemed to be overrun by bronchial kids on their way to Australia. We were glad to disembark at Santa Cruz airport to be met by a sun-tanned Cameron Beck, impressively attired in full colonial tropical kit: khaki shorts, military shirt, solar topee, and less appropriately, white socks and sneakers. We were to discover later that these were, in fact, the only garments he possessed, and when the sneakers finally disintegrated in the Egyptian desert, he was forced to complete COSMOS in bare feet.

Soon I was able to meet some of our Indian crew, and inspect some of the facilities we were to hire from Madras Studios. The crew bus was a very impressive Leviathan complete with darkroom, make-up room, cold store, work bench and masses of storage space. I was able to obtain sufficient large reflectors, and a good platform dolly and track. The lighting equipment I had ordered was not available to view, as it was in use. Film equipment in India is hard to come by and works 24 hours a day, seven days a week in their thriving industry. It is usually quite old, but in good repair, and we were never to be let down by any of the equipment hired locally, or by any of the first-class technicians who worked for us.

The small southern town of Thanjavur where we were to be based was well away from the established tourist routes. Our hotel, Raja's Rest, proved simple but comfortable, and we were looked after with every consideration. We were even given two early morning calls each day, the first at 4 a.m. when the crows in the trees of the central courtyard woke up,

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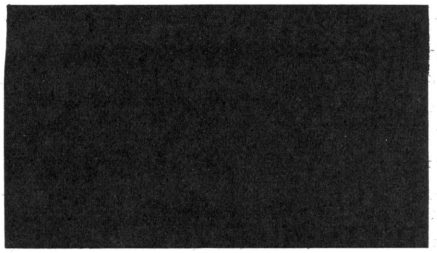

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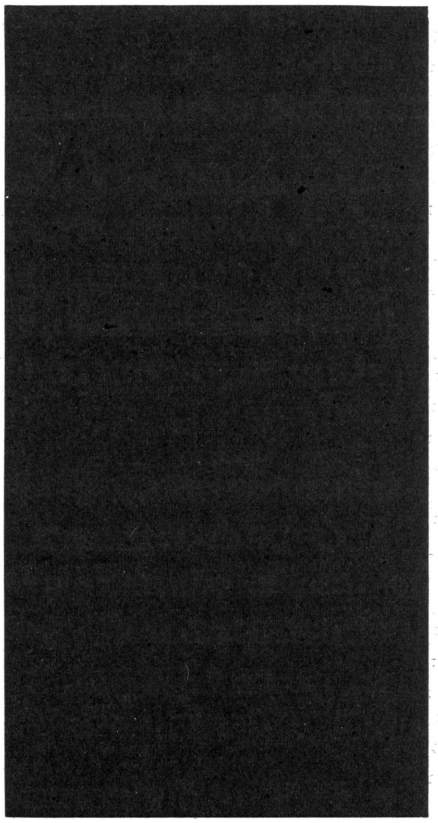

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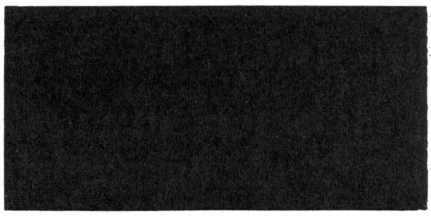

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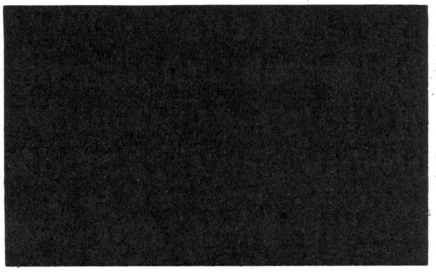

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THE SPACESHIP OF THE IMAGINATION

Continued from Page 1004

allow us to establish the impresson of movement more easily. To truly create a feeling of the ship moving through the Cosmos, the lighting had to be motivated by what was happening in the window onto space. The ship would be lit by the light from space and in keeping with our desire to create a total experience Morris was told that he must light the entire ship at all times. We would not light for specific camera angles. His job was to make the entire set fly; our job was to capture that on tape.

In the spring of this year all the elements came together for the first time on KCET's Stage B and we finally had our "ship of the imagination". Our production schedule allowed us five weeks in which to tape all the COSMOS spaceship scenes. The visual effects were broken down into segments of from three to six minutes. The lighting designer had used videotapes of the effects for timing and design purposes, but the actual lighting board programming for each scene had to be done while watching the effects projected within the set. Minor timing errors between the visual effects in the window and the lighting effects on the skin of the ship would destroy the illusion of movement we were after. Up to 170 cues were used for a three-and-a-half-minute sequence, with each three-to-six-minute sequence taking up to twelve hours to program.

Morris' lighting design broke the ship into six areas along each side and down the interior of the set. Those eighteen lighting areas allowed him to "walk" the light down the ship as we came upon and passed objects in space. To accomplish this he used 252 lighting instruments, each on its own dimmer. He chose 1000-watt Par 64's and 6 X 9 and 6 X 4½ ellipsoidals for templates and patterns. Fifty-four of the instruments had motorized color wheels placed in front of them. The clear acrylic wheels were bent using a blow-torch so that the light passing through them was bent and distorted. The wheels were painted in various shades of a particular color. When turned in front of an instrument gelled with the same color medium, the resulting light changed in hue and saturation.

To control the lighting, Morris chose the Century Light Palette. Its computer operation and floppy disc memory gave him the control and flexibility he required. When none of the light palettes was available for lease, Morris personally purchased one because he believed it was the only lighting board which could give us what we wanted. That degree of dedication is what made the spaceship a

success.

Morris and Associate Director Sharlene Bellanger were provided with a digital readout from the effects projector which allowed them to have a frame accurate reading of exactly where we were at all times in each visual effect. From her location in the control room, the A.D. would program the projector to stop or make a series of speed changes by keying the appropriate frame numbers into the projector control panel. After watching the effects and lighting together, a decision would be made on whether to speed up or slow down a particular part of the effect. The long computations required to make speed and framecount changes were loaded into the memory of a programable hand computer which resulted in calculations that were quick and reliable.

We recorded an average of six to eight minutes of material each day. All the spaceship sequences were shot single camera, which allowed us greater flexibility and attention to individual shots. The new RCA cameras performed exceptionally well, allowing us to shoot all the ship scenes with 15 to 30 footcandles.

We used a number two fog filter on the camera to create a more imaginary image quality with the resulting halations reinforcing the dreamlike feel of the spaceship. The camera was mounted on a Chapman Nike crane and fitted with a special wide-angle Angenieux zoom lens. The increased horizontal field-of-view from the 14.5mm lens added tremendous depth and dimension to the set. The very low light levels at which we shot caused an unacceptable amount of noise in the video signal, so all the completed tapes were noise reduced at Image Transform. The combined low light levels, fog filter, and noise reduction resulted in images which have a texture and softness unlike the crispness usually associated with video.

To create our "spaceship of the imagination" it was necessary for us to reach out and embrace new techniques. The ship exists because we learned to refuse to accept the fact that what we wanted couldn't be done, or that it couldn't be done within our budget. It was a work of incredible love and dedication. Special thanks must go to Associate Producer Judy Flannery whose patience, understanding, and talent guided us through the experience. Additional words of appreciation go to technical director Cal Slater, video operator Greg Harms, cameraman Ron Graft and his exceptional crane crew, and to stage manager Steve Wyskocil. They are only part of a long list of people who made the COSMOS spaceship a ship of their imaginations. ■

and that's good. A lot of rules could be broken. I mean the whole business of the engineering and the many things that had to be invented to do this—you couldn't have done that at the BBC. It would have taken three years, it would have been terrific when it got there, but I mean it would have had to go through the whole engineering division and at least 45 people would have had to have an input and it would have had to be tested in the test laboratories and then they would have come proudly and said, "Here is your machine." And you'd have said, "That's fine, but the series went out two years ago." That we didn't have to do here. For instance, in this whole enterprise—I've now been with it three years from its first thinkings—I have written, I think, about six memoranda. That's the only thing I've written. Other people have generated a lot of paper, but if I can actually control everything from this desk and just walk down the corridor or pick up a telephone, that means I'm cutting through red tape and you will find in all of the files only six memoranda from me with my signature on. You couldn't do that at the BBC—that's for sure—or CBS or NBC or any large organization. So that's a statistic that tells you something about the stripped-down nature of the operation.

QUESTION: In Hollywood, especially during the past few years, there has been a spate of feature films that have run enormously over budget. Part of this has been due to ineptness, but some of it has been the result of the quaint idea that artistry, or "genius", if you will, should not be constrained by anything so mundane as budget. How do you feel about that?

MALONE: Some of the greatest artists who ever lived were concerned as much with budget and rigor and discipline as they were with art. Genius rarely comes along and most of the people who call themselves artists are actually artisans. If you are called an artisan that is the greatest compliment anyone can pay you in the film business. To call somebody an artist . . . Hummmmm . . . I worry a bit about that. I think there have been very few artists in film, because they rely so much on other people. So, therefore, whose is the creation? I can't take credit for all the things in COSMOS that are on the screen, although I'm called Series Director and Executive Producer. I can't, because it is the work of many people and we are all artisans and when we put our artisanship to-

gether it maybe turns out a piece of art, or maybe not. If it does turn out a piece of art, that is fine, but who the hell is the artist? They are all artists. You see what I mean? I'm with you on that. I would hate to have a budget which is big enough. I think it would make me run screaming and try to resurrect Eisenstein or something. I take a lot of pride in coming in on budget and so do my people.

QUESTION: COSMOS, almost by definition, is a spectacularly dramatic subject, and yet it has an almost coldly sterile beauty to it. The temptation would be to put that cold, sterile beauty on the screen in terms of so much celestial design, or whatever, and let it stand that way, but you have managed to humanize it very, very successfully, judging from what I've seen. Can you tell me about your approach to doing that?

MALONE: I've always thought that once the Big Bang happened, then, with hindsight, consciousness was inevitable. Now, consciousness may exist elsewhere. It probably does, and in many more forms than we know. However, the only consciousness that we do know, and are conscious of, is our own. I don't know what a dog thinks of the universe, or a dolphin. I wish I did, and if they do at all. I don't know what somebody in another galaxy or another planet thinks. I wish I did, but I don't and, therefore, all one could do was say that the central plank here is to say that the only way of knowing the Cosmos is to know that man exists. That's the only way we have. Therefore, that must be reflected. Secondly, there is a straight line from the Big Bang to us and to all life, to all things, and the same atoms that started there, exactly the same bloody atoms, are in you and me and this desk and everything else. They are just the same after 15 billion years. Now, nobody seems to make that connection. I think they are beginning to get it. So what one had to say was that we are all deeply a part of the Cosmos. The Cosmos is deeply a part of us. They all sound like mystical statements. They are not; they are very scientific statements and, anyway, I have no problem whether they are mystic or scientific. They are true, and so the humanizing of the thing was really very easy. What one had to do was tell a lot of stories because there is no better way of explaining the unified field theory, if it exists, than by saying, "Once upon a time." I mean, if you can't do it that way then it's probably not right. So all one does is always tell stories. Stories usually involve people, because that's the only way we see ac-

tion happen. We have told stories about whales and we have told stories about mythical creatures, but the mythical creatures, if you believe Jung, are only in our head anyway; they are only a product of the right brain. So, as for the humanizing of it, if we had done it any other way, then I think we would have been telling a lie. We would have been telling a theological lie and a scientific lie. Sagan himself is someone who obviously enjoys being out there, I think, more than he enjoys being here and so that was a fairly easy thing to reflect.

QUESTION: Considering the enormity of the COSMOS project and the horrendous amount of work entailed in completing it, are you at all amazed to find that it is finally a finished product?

MALONE: The thing that continually amazes me is that you lie in your bath in the morning and you think of something as you are gazing at the ceiling and seeing all sorts of shapes and things and creatures and systems and pictures and hearing music and sound, and you forget it and you go off and have breakfast and you putter off to a very mundane life and three years later the damned thing is on the screen and you've spent eight million dollars. That is true amazement to me, and also, that so many people have contributed to that vision and made it so much better. The amazement is not at what's on the screen—I never watch what's on the screen; I never watch a series that I've done on screen. It's the process which is important and I hope people enjoy the product, but if I were asked why I do this, I would say that I do it for myself—and I suspect you would get the same answer from a lot of the people working here, if they were really honest. People ask me, "What segment of the audience did you make this for, Mr. Malone, what age group? What sort of habits do these people have?" Frankly, I haven't the faintest idea. I will trot out some jargon that I happen to have read in VARIETY or the Nielson ratings, which I don't understand. I do the bloody thing because it's an education to me and a pleasure—and that's all. The pleasure is in watching the intricacies of the efforts of all the people that you bring together to do this, and you think, "My god, if you put all of this intellectual and creative power into one place, there is nothing you couldn't achieve, nothing at all!" That's the amazement of doing one of these series, and unless you have that amazement, you just can't go on. The thing becomes a bore. ■

"COSMOS" CINEMATOGRAPHY
Continued from Page 1059

and the second at 5 a.m. when the temple music commenced. We were pretty glad to get to work at 7 a.m.; we'd all been awake for two hours by then.

The initial shooting did not present any insuperable problems. How to carry heavy equipment across soggy paddy fields (up to our waists in water)? How to get lunch 30 miles from the nearest village? David Oyster had created an excellent rapport with the locals, and our arrival at every location was met with gentle smiles of welcome.

We filmed the village and agricultural working life of the people against a stunning background of green paddies, temples, and waving palms. India is without doubt one of the most beautiful countries in the world, and the cameraman is faced with the difficulty of choosing between a thousand fascinating and beautiful images. The preparations for the Pongal festival were to provide a background for Carl Sagan's explanation of the various concepts of the origins of the universe. By the time he joined us we were setting up for the long tracking shots through the palm trees, that would enable him to walk through the landscape whilst talking to the audience.

Blisters on the feet were a common fate for anyone standing still for more than a second on the roasting flagstones of the temple of Daresuram. I can recommend these conditions for making a crew work quickly. The almost vertical light gave me problems with dense black shadows, but we were able to use the large reflectors placed well back out of Carl Sagan's eyeline with the camera. The equipment all functioned perfectly in 110° heat.

In order to film the world famous Shiva bronzes in the museum of Thanjavur we had ordered an Elemak Octopus dolly which duly arrived by train from Bombay along with a grip who proved to be one of the best dolly operators I have ever worked with. We set up the priceless bronzes on a small stage within the museum, and draped all four sides with black cloth.

Lighting had arrived from Madras accompanied by seemingly dozens of electricians. I never discovered how many there were, but I believe that when pay day came, and the eager electricians formed a queue for their wages, their ranks were swollen by several enterprising locals. They were excellent technicians but had a noticeable reluctance to leave any light on a moment longer than was necessary. This, they explained, would prolong the life of the incandescent bulbs, which were scarce

and almost incredibly expensive in India. This meant that the moment David Kennard said "cut", we were plunged into Stygian darkness and confusion.

The generator thundered gently in the background, an unblimped monster requiring hand priming with dangerous-looking jam-jars of diesel fuel poured directly into the cylinders by a chain-smoking operator. The device had arrived from Madras balanced on a gaily painted truck, as though it had lost its way from a fairground. It took half the population of the town to guide it, with ¼-inch to spare, through the gates of the museum. When the light eventually fell on the stunning forms of Shiva and Parrathi, all the effort was worth making.

EGYPT

We arrived in Alexandria after a very long journey from Thanjavur, still in our tropical kit, to be met by director Tom Weidlinger, Producer Geoffrey Haines-Stiles, and perishing cold and stormy weather.

Filming in the Middle East has its own particular problems. Whenever your camera appears, however well it is concealed, about 300 small children appear and wave and dance in front of you. Even the application of Baksheesh only temporarily cures the problem. Poor Cameron Beck was kept busy chasing them away. We filmed on the streets of Alexandria, by candlelight in catacombs, and on the top of a windy Roman lighthouse. We never got warm, and depended on our duty-free whisky for comfort.

The second part of the Egyptian sequence took us to sunshine and Luxor, situated on the banks of the Nile in the southern part of the country. We were to reconstruct the journey taken by the Frenchman, Champollion, during which he visited the temples at Karnak and Dendera. A lifesized fibreglass model of the Rosetta Stone had arrived in a huge crate from the British Museum in London. It was as light as a feather, and though 3 feet high, continually fell over in the light airs that wafted gently round the temples.

The sequences on the river Nile were the most difficult for director Weidlinger and the film crew. The Feluccas looked fine, the French artistes playing Champollion and his men were perfect, the sun shone; but the wind changed direction, the towline broke, the current swirled, the camera boat became stuck on a sandbank, enormous floating hotels heaved into shot, and the batteries on the walky-talkies went flat. Our Egyptian crew, becoming excited, shouted very loudly at each other. The confusion was perfect, and greatly entertained the locals along the river bank.

Night shooting in the isolated temple at

Dendera was an eerie experience no one is likely to forget. We were able to borrow a small portable generator from a nearby archaeological dig which allowed the use of three of my 650W 120V Ianiro lights. With the addition of hurricane and tilley lamps we were able to light large areas of the temple for Champollion to discover. I filmed entirely with high-speed Distagon lenses and used a single net (fine black nylon stocking) to add to the mysterious effect of the location. The peculiar feeling associated with this place clung to us for days, it was as though we were haunted by the ancient gods and men of the old civilisation.

We completed Carl Sagan's pieces to camera by the Pyramids at Giza near Cairo. This is an area much sought after by tourists and their attendant locals, and it was frequently difficult to set up the shots we wanted, as soon after the clapper-board was put on a stout matron from Omaha, Nebraska, perched on a camel would sway into shot. Little heads of helpful guides and porters would pop up from behind rocks in the middle of takes without warning. The powerful personality of Asma el Bakri, our fixer, was put to good use in these circumstances.

GERMANY

The location in the Abbey at Maulbronn, South Germany, was not only authentic but made a perfect background against which to film the schooldays of astronomer Kepler. The building is beautifully atmospheric, and with the aid of some additional lighting equipment sent out by road from England, I set out to attempt to capture the feeling of the ancient buildings. I used the high-speed Distagons even for daylight sequences, and deliberately underlit. I very much like the discipline of prime lenses, and find the Zeiss series to have a very fine image quality.

AUSTRIA

The famous Armoury in Graz, Austria, provided the location for a very different kind of sequence. The building is crammed with armour and weapons from the endless European wars of the 17th and 18th centuries, and we attempted to shoot an impressionistic sequence symbolising the dangerous and unstable society of the period. The highly polished surfaces of the armour gave us plenty of lighting problems, but fortunately Geoffrey Haines-Stiles had scheduled enough time for us to light very carefully, avoiding endless reflections and hotspots.

CZECHOSLOVAKIA

Arrangements had been made with Kratkyfilm of Prague to provide a production package which included lights, dolly, track, and electricians and grips, as well as full production facilities and artistes. I believe this was the first such production deal made by an American company. The Czechs were very keen to inspect the Aäton, there is no comparable camera in Eastern Europe.

Prague is a perfect setting for period reconstruction. Carefully rebuilt after the war, very little needs to be done to enable large sections of the city to be used as backgrounds. There are few traffic signs, no yellow parking lines, and large areas are permanently pedestrianised. The few discreet shop signs can easily be disguised with careful set dressing.

A restaurant in the process of being reconstructed became Kepler's classroom. I attempted to produce a lighting plot which would enable the director to shoot from most directions, thus reducing the amount of re-lighting time. Despite the language difficulties, the Czech lighting crew and I were able to communicate without any problem at all from the start, thus proving that the language of film technicians is universal. Equally universal is the love of good beer, and our friendship was sealed by the purchase of several crates of delicious Pilsner. I have seldom worked with a more efficient, helpful, and responsive crew, and in every location, day or night, their hard work made our punishing schedule possible.

ENGLAND

Our final involvement in COSMOS was on home territory. The village of Colne St. Aldwyns became H.G. Wells' village for a mysterious "War of the Worlds" sequence. The entire population of the neighbourhood and most of the film crew arrived dressed in Victorian clothes. Trinity College, Cambridge, provided the setting for a discussion of chemical elements and mathematical infinities.

Throughout all this time our Aäton, Zeiss, Nagra, and Ianiro equipment had worked faultlessly. I recall two takes reshot because of foreign bodies in the gate, in the thousands of feet we shot. We had the pleasure of working with expert teams in India, Egypt, and Czechoslovakia, and all of us learnt new techniques and new answers to old problems. ■

CREW:
Chris O'Dell, Lighting Cameraman
John Page, Sound Mixer
Pete Rees, Assistant Cameraman
Len Emery, Electrician
Larry Prinz, Electrician

SPECIAL VISUAL EFFECTS
Continued from Page 1012

step with new scientific discoveries. An earlier model, and the shot of Venus were rejected, even though Adolf Schaller spent considerable time painting a beautiful cloud backdrop, and Yellowstone Park-like paint pot sulfur pools were built into the model. Russian-Venera and American Pioneer data was being analyzed and released at this time in increasing amounts. Rick Sternbach had already begun the building of a new larger Venus model that would afford us wide vistas—we wanted to see a vast plain complete with molten rivers of lava. No vista, no lava. New data in the midst of our model building suggested that the atmosphere was rather dense at the surface—to be accurate we couldn't see very far, and because of this thickness the surface would now seem to ripple and distort. Some surface pictures were returned from *Venera 9* so we had to start making hamburger-bun-like rocks amidst mud cracked fields. Sharply differentiated layers of cloud density, corresponding to altitude, and atmospheric lightning (at a frequency of 25 flashes per second) were reported. Redesign the effect. Don Davis builds a new model including a rather byzantine-looking miniature Venera spacecraft. This is where we used a tank to simulate a variety of cloud textures and densities, by injecting chemicals, mostly milk, into water.

Shooting at high speed, with strobes built in to convey the lightning shimmer, we managed to obtain "pieces" of the Venus atmosphere which were then selected for optical linking to match a cross-section cloud density chart of the Venus atmosphere supplied by writer Steve Soter, based on analysis of new data. Accurate cloud and surface color guidelines were provided by a computer interpretation of Venera's newly released numerical data by matching this to scientific color chips. This was a first. We were thus reasonably accurate in our coloring of the effect, with extra efforts of our timer, Dave Pearson, at CFI. Even so, we couldn't quite get the fullest peachy color we wanted. Think peachy when you watch this scene in Episode Four. The heat shimmer effect on the surface was optically built in with a rotating glass at Modern Film Effects. John Allison later rotoscoped the lightning bolts to enhance the built-in distant shimmer from the tank shooting. Next time you do space effects plan it on the other side of real voyages in space, not simultaneously. Who says film waits for no one?

At the same time we needed to finish our tour into our solar system. Earlier attempts to project painted planet trans-

parencies on hemispheres did not give us the effect we wanted. Nor did a cost-saving attempt at hand-done shooting of planets and backgrounds.

We would need an elaborate motion control repeating system to shoot planets, moon, starfield, corresponding holdouts. We needed a track camera system long enough to bring planets from a small point and pass by closely. We needed more control accuracy than the system used for our multiplane effects. The level of complexity rose. We needed eleven shots in a couple of weeks. We spoke to many effects houses who gave generously in trying to help us out. Universal Studios' comprehensive Hartland facility came to the rescue. Perhaps it was the challenge to execute scientifically based effects after the exhausting shooting schedule of BATTLESTAR GALACTICA and BUCK ROGERS that intrigued, first, Peter Anderson, Hartlands' Technical Facility Manager, and through him was contagious to the rest of the crew. They did a first-rate job, even constrained by our limited time and dwindled budget. COSMOS's Executive Production Manager John Macker was as creative as anyone at this time.

New shots were designed. System limitations and scene design are like the chicken and the egg story—you're never quite sure what goes first, but you know you can't separate them. One very important lesson we had learned by now was, emphatically, that simple techniques are usually the best. There is often a tendency to showcase technique nowadays, with the incredible explosion of endless people doing effects. Sounds simple. But we've been through it. Too much time is wasted trying to make technical systems do what they won't. Hartland knew this and we were grateful. Though this is not to say we didn't do complicated shots. John Allison, with the Hartland team, spent many days rigging our shot of Jupiter, which had a number of moons and needed lightning flashes on the dark side! Twelve elements in all. Though we also did some opticals at Hartland, production schedules of their other shows required us to finish our opticals at Modern Film Effects, some also at Cinema Research. Precision Film Group in Santa Monica also helped out with the completion of a couple of planet shots; and later shot one of our more complicated sequences, that of our travel through the interior of a white blood cell to the nucleus. This shot required difficult bipacks with ultimately "nine matted elements all moving, but not against black, like most high-tech multiple element space shots," comments John Allison, Visual Effects Supervisor. Opticam, also of Santa Monica, got us through a lot of

shot crunches at a time when we were in tight production time frames.

SOME LESSONS

Somehow I felt like Holden Caulfield. After all of this things aren't quite the same. Lessons were learned. Just some . . . things like, technique testing always pays off; or never quite believe any effects cost quotes—it's always two to three times more somehow, even with "fixed bids"—you always want to change something. Use this as a rule of thumb and you might be "just" safe budget-wise. Effects take twice as long and then some. Built-in flexibility, for aesthetic changes, production schedule re-arrangements and budget, are critical. Lots of flexibility. Don't do the job unless everyone around you understands this. You'll have tremendous administrative headaches; be surprised at the enormous different variety of visual pictures people have of what an effect might be before shot; be surprised at your own wanting to change things even though the first shot came out exactly as you thought it would . . . if we could only change this one little thing. You'll be frequently and terribly frustrated at the slowness and precision of effects execution, the redos, the redesigns, and the things that go wrong, with the rest of the show needing the shot yesterday. And a bit regretful that you couldn't do all of the things you could dream of. If not with reality, then at least with effects, our ability to imagine still manages to exceed what we can do. Even so, it's worth it.

Many of the effects in COSMOS give a marvelous glimpse of the unending wonders of our universe. All of those who contributed to the COSMOS visual effects, certainly well over a hundred people—artists, scientists, cameramen, programmers, administrators, the list goes on—deserve deep thanks for huge patience and generous energy. What we did achieve belongs to all of them. ■

DREAMING TO SCALE
Continued from Page 1054

renderings of the neural network, Jimmy Dow built our model. No one had actually seen a neural network in any form. There were micrographs of nerve bundles but none of the entire network. The artist represented the network as a vast cavern filled with biologically accurate neuron shapes. To Jimmy Dow it became a tubular aluminum frame supporting a large array of mass bundles, insulated wires and resin casts of rhubarb roots. Jimmy used various combinations of castings made from molds taken from the tubors of rhubarb to build the neurons of our brain. Carl stood on one such neuron to explain how the network works. In post-production we built video mattes and overlaid the flashes onto the neurons. The realism of the neural network model achieved through a simple solution was amazing to us and our brain consultant, Dr. Arnold Scheibel.

REALITY

How we would integrate the Magicam video sequences into the final 13 episode composite was another problem to solve. A Magicam video sequence might be preceded by or followed by a film element. So we decided that the crisp, see-forever look of state-of-the-art video was not what we needed. Instead, Magicam suggested that the old Norelco PC 70 cameras would give us a softer, richer pastel look. It would be closer to film and it would allow us to do some video painting on the backgrounds to augment lighting. Lighting was especially important because we needed each sequence to seem real. What Steve Burum achieved was a well-balanced look on both stage and model. Beyond these two considerations, camera type and lighting, there were no overall conceptual guidelines or restrictions. The Magicam system allowed us to experiment and explore the technology's potential.

The overall Magicam experience was enlightening, especially for someone like me who had worked principally with film. Unlike film where there is a lag between execution and evaluation, video allows you to see immediately the results of the special effects. Using video to create electronic mattes and background permits greater latitude of experimentation. You can adjust until you get the desired effect. And you can do it in a matter of hours instead of weeks. But that is not to say that video effects are simple, or instant.

For instance, to get a full Magicam shot involving stage and snorkle camera, the basic camera move has to be blocked out with both cameras. Both model and stage have to be lit—the model for look and the

stage for matching with background, and to generate the subject's shadow. And that has to be matched with the overall even light for the blue set which is necessary to achieve a clean matte. The video engineer then must composite the picture without allowing any breakup in the subject, the subject's shadow or the background picture coming from the periscope camera. Then, if the grips don't have a problem or an arc light doesn't start to flicker, you can get off your first shot of the set up. Even so, visual effects can be created via Magicam that cannot be done otherwise.

Preproduction planning is the key to maximizing the Magicam system. Tightly scripted and storyboarded sequences enable you to move quickly from sequence to sequence. To wing it is time-consuming and expensive. In the case of COSMOS, winging it was unavoidable. Because of our crushing production schedule, (we had to shoot forty worldwide locations and nearly ten weeks in the studio in less than a year), there was little time for detailed scripting or rehearsal. This led to compromises in coverage, since so much time was spent working out sequences moments before shooting. Therefore, we were not always able to achieve the optimum that the system could deliver.

Magicam's hardware makes its own brand of fantasy. But it is the Magicam team, the people who make the machines work, that makes the magic happen. They are totally committed and dedicated to the best possible product. They never said no.

In the end, about 50 minutes of COSMOS' 13 hours are full-screen Magicam effects. Although it was time-consuming and frequently frustrating as is any special visual effects effort, the Magicam system achieved wonders. Magicam helped make the COSMOS dream a reality. ■

"COSMOS" ON LOCATION
Continued from Page 1045

their richness.

A New England couple's close encounter with a flying saucer was best rendered as a "B" horror film. I decided to use some *genre* elements—rain, wet pavements, and lightning to create tension. Claustrophobic framing on choker closeups added to the suspense. The overall impression was that frightening aliens were just beyond the headlights, outside the edge of frame.

Because of budget considerations, I had to turn to early cinemagraphic techniques to put Canterbury Cathedral in Griffith Park. I wanted a long procession of 12th-century monks filing past a glowing crucifix. But I only had five monks. They were wearing robes with hoods. So, in the spirit of Mack Sennett, I had them file by the crucifix, circle behind camera and change their hoods—if they had been down, they came up, and vice versa. After the hood change, the actors quickly rejoined the line and passed through frame again, and again. On film, the scene moved along with no apparent break in the flow of monks nor was there any obvious repetition of actors.

These monks had to be shot outside Canterbury Cathedral in England, but we didn't have the budget to do it there. So, at minimum expense, we brought Canterbury to Griffith Park. It was made possible through the magic of glass painting, an all but forgotten art. Glass painting is an invaluable technique for stretching production dollars and increasing location versatility.

In Holland I also used the glass-painting technique to put two apparently full-scale seventeenth century Dutch merchant ships in the harbor at Enkheuizen. Glass-painting has a wide variety of applications. For COSMOS, it was a reliable location effect.

COSMOS was a challenge on a grand scale and it was an opportunity to experiment with a variety of cinematographic techniques. ■

ON TRANSPORTING AN ENGLISH VILLAGE TO THE VICTORIAN ERA
by JANELLE BALNICKE

The year is 1894 . . . the era of steam traction engines and horse and cart. The assignment . . . recreate a day in the life of a typical English village—a day that H.G. Wells might have enjoyed—the summer village fete. As annual fundraisers for the local parish, summer fetes are still common throughout England, but rarely do they attempt a total transformation into the past. One tiny Cotswold village, Coln St. Aldwyns, agreed to join forces with us to co-create a time

warp for two days. Together we produced a full-fledged Victorian fete with roundabouts and swingboats, steam organ, flower stalls, tea and croquet on the Vicarage lawn, "Punch and Judy" show, a deer roast and a tug-of-war.

As a co-production, we were able to maintain a "presence" in the middle of Gloucestershire consistently for the five months leading up to the film date. Our local "fixer" was the Reverend Derek Cowmeadow who willingly converted his Vicarage into the central production office. With diligent assistance from his "Committee", he proved to be a stalwart location manager.

Though the fete was open to the public on the first day of filming for fund-raising, the villagers agreed to return in costume as extras on a second day so that we could have greater control over the events. On the open, public day, we worked in the documentary convention of non-interference, shooting closeups and allowing the events to follow their own natural course.

The second day gave the director, David Kennard, an opportunity to reconstruct more complex scenes, including several crane shots from high above the Vicarage.

Among the other advantages to this type of cooperative co-production was the sense of realism and spontaneity from filming non-professionals. The fact that the fete remained essentially a locally produced event also assured a greater degree of cooperation from the villagers, due to the amount of real involvement and interest which they had in all aspects of the production. We were partners, not invaders, and, as a professional experience it enabled us to accomplish a large location production for a fraction of the time, expense and difficulty normally associated with such an undertaking. And, finally, it provided an unequalled sense of personal joy resulting from the unique working relationship which allowed us to become a part of this small English village. ■

HOW BAKSHEESH MAKES THINGS HAPPEN ON LOCATION

by CAMERON BECK

Much of the success of managing the logistics for a film unit on location in one of the developing countries hinges upon the timely and proper application of that most ubiquitous of economic lubricants, *baksheesh* (or simply *'sheesh* as it is usually hissed in one's ear). The following account serves to illustrate what can happen when an inexperienced Production Coordinator (myself) failed to administer *baksheesh* correctly.

The incident in question occurred at the Santa Maria Airport, Bombay on the

night of 20 January 1979 as the COSMOS film crew was preparing to depart India for our next location, Egypt. David Kennard had decided to fly directly to London with our exposed film and David Oyster was wrapping the locations on the other side of the sub-continent. That left me as senior, indeed, *only* representative of the production team and responsible for the film crew's safe arrival in Egypt.

My main concern upon arrival at the airport some two hours before our scheduled 2:15 a.m. departure was to see that our thirty cases of film equipment were all accounted for, checked in and cleared out of the country. This last operation was a necessary Customs procedure to ensure that we had sold none of the gear in India.

Upon checking in I learned that the official excess baggage charge for our thirty cases Bombay-Cairo would be $2000. This seemed quite unreasonable and the situation clearly called for *baksheesh.* A delicate negotiation was carried out with the baggage clerk and a figure *seemed* to have been agreed on: 800 rupees or the equivalent of U.S.$100. I handed over the last of my Indian rupees and awaited the necessary baggage receipt. Forty-five minutes later we were still waiting while the clerk continued to scribble in quadruplicate. What with the clammering shoals of passengers all vying for his attention, he had plenty of excuses for holding us up. But it was becoming increasingly obvious that more *baksheesh* was expected. There was, however, nothing we could do, having exchanged our last rupees. I asked the Government of India Tourist Officer who was assisting us if we should not inform Customs so they could inspect our equipment. "No problem. Later," was the cryptic response but there wasn't much later left. It was now 1:45, half-an-hour to departure and we had not even begun the embarkation formalities. I was beginning to sweat very hard.

Finally, at 2:00 a.m. we received the necessary baggage receipts and sprinted to the other end of the terminal where the Customs officials stood like a group of admirals in crisp, white uniforms. The official took the equipment manifest and looked up at me, startled: where was the equipment? In the Air India baggage area. An Air India official was summoned. No, the equipment had gone out to the aircraft and had been loaded. My head reeled. The admirals conferred briefly: the equipment would have to be off-loaded and brought into the Customs shed for inspection. But, I protested, we would miss our flight and our tight film schedule would not be met. The admirals wagged their heads as only Indians can and shrugged. The situation

was desperate indeed.

At this point I realized that only an inspect in the hold of the aircraft itself would meet the requirements of both Customs and ourselves. I broached the idea with the most sympathetic looking Customs official. His face registered horror. Oh no. Absolutely out of the question. It was not permitted. More appeals. References to the fine assistance of the Government of India in setting up locations. Another conference of the admirals was called, this one considerably louder and more intense than the last. After some minutes of heated debate a decision was reached: I would accompany one of the officials out to the aircraft and an inspection would be made there. It was 2:10.

As we rode out across the floodlit apron filled with aircraft either disgorging or taking on passengers, ne had a true sense of Bombay as an Asiatic air crossroads. We paused while an Aeroflot jet taxied loudly past, and short cut under a Pan Am 747 to reach our Air India 707. There was still considerable activity around the aircraft, indicating that she was still some time off from departure. Nevertheless, the ground crew stopped their scurrying preparations long enough to watch amazed as the white suited Customs official and I rode the baggage conveyor up into the 707's rear hold.

Once inside that dim space, piled high with suitcases, the size of our task became grimly apparent. Digging in among the bags I was finally able to unearth several of our cases. But locating thirty film cases by rummaging around the mass of bags in that 707's hold was clearly an impossibility. After a cursory inspection of the cases I had managed to find the Customs official signed our equipment manifest and the COSMOS film unit was once again on its way. The nearly disastrous lesson of the *baksheesh* would not be forgotten by this Production Coordinator. ■

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16mm CUSTOM triple headed optical printer $5000. DAVID MCCUE, 14836 Polk St., Sylmar, CA 91342 (213) 367-3580.

EQUIPMENT FOR SALE

COOKE Kinetal lenses, Arri standard mount 9mm, 12.5mm, 17.5mm, 25mm, 50mm & 75mm, $400 ea. Complete set $1950. Angenieux 9.5x95 CA-1 mount, $1750. Zeiss 10x100 CP mount, $1000. O. H. H IRT, INC., Phila. (215) 629-8562.

ARRI 16SR w/2-400' mags, 10-150 Angenieux zoom, 2 on-board batteries, adapter, charger, handgrip, barney and cases, excellent & condition. (213) 874-0811.

WORRALL head, small wheel & case; mint, $4000. 12-120 Angenieux C-mount, $1200. 50mm Schneider, $50. 150mm Kilfitt, $150. Spectra Pro Meter, low scale, $125. (213) 994-1055.

B&H 16mm PROJECTORS, 1 302 O/M sound, $425. 1 302 O/M sound, $485. 1 545T optical sound (line new), $425. 1 Super 8 sound recorder, XTAL sync at 24 fps (new), $450. Pan-Cinor 12-120, T3.3 zoom lens, C mount, $650. JAY C. BROWN, 25 Kensington Ave., Salt Lake City, UT 84115. (801) 487-1344 AM, 266-5773 PM.

Brand New NPR Eclair package $1101, current price list minus 25 percent. MARZ ASSOCIATES (312) 534-2379.

PETERSON 16mm color printer with 22 step semi-automatic shutter, fader, soundhead, picture and sound power supplies, double air vacuum film cleaner, air vacuum pump, in excellent condition, presently in use, $5800. or long term lease. MURRAY HILL PRODUCTIONS, (212) 586-0355.

SUPPLIES

BLACK LEADER, 16mm, fresh stock processed to 4.0+, guaranteed $.05/ft., min. order 2000 ft., Complete lab service and supplies. 16mm & Super-8 LEO DINER FILMS INC., 350 Golden Gate Ave., San Francisco 94102 (415) 775-3664.

16mm Black leader (Kodak) processed to 4.00 density $55.00 a 1,000. 16mm NP splicing tape, $1.75 a roll. 16mm DP splicing tape $5.75 a roll. Permacel Gaffers tape 2" x 60 yds. $8.75. Photo lamps 30% off. Fiesta leader colors, $18. a 1000'. Just samples send for a catalog or send us an order. TALIS ASSOCIATES, 5221 Wisconsin Ave., Washington, DC 20015. (202) 244-0901.

BLACK LEADER, from East Coast 16mm, fresh stock processed to 4.0+, guarantee, $.054/ft. plus shipping. No Min. Clean room negative editing service available 16/35mm. CONNECTICUT EDITING SERVICE, 297 Dunbar Hill Rd., Hamden, CT 06514 (203) 288-1753.

SERVICES AVAILABLE

QUALITY CAMERA SERVICE
Complete repair and machine shop, parts department, and top experienced technicians are available at Birns & Sawyer, Inc. to service your camera, lenses, tripods, and related equipment. Send in your equipment for an estimate to our Service Dept.: Call (213) 466-8211 PETER ANWAY, Birns & Sawyer, Inc. 1026 No. Highland Ave., Hollywood, CA 90038.

STEADICAM RENTALS for CP 16R or RCA TK 76 cameras. Also available CP16R cameras & Cinevid. OSCAR H. HIRT, INC., 35 No. 11th St., Philadelphia, PA 19107 (215) 629-8562.

MAN/WIFE TEAM, experienced in film production/seamanship. Share: responsibilities, expenses, profits. "In the Wake of . . . ." TV series. OCEANIS FILMS, Box 4865, Vancouver, Canada V6B4A6.

QUALITY REPAIRS on Bolex, B&H Filmo, Auricon, Canon Scoopic, CP-16, etc. Angenieux lens repairs using genuine Angenieux parts and test equipment. Also Canon, Fujinon, Switar, etc. KENNEDY'S CAMERA & LENS SERVICE, 406A North Main St., Euless, TX 76039. (817) 283-8321. Sales & Service.

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RENTALS

ARRI MULTI-CAMERA systems for features and TV film productions: Arri 35BL; 35III; 16SR; 16SR/HS; Video Assist; Zeiss super speed lenses, much more. Attractive rates: Write/Phone: ROESSEL CINE PHOTO TECH: 48-20 70th St., Woodside, NY 11377 (212) 424-1600.

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HOLLYWOOD editing equipment and room rentals. Also complete editorial services. CRAWFORD EDITORIAL, (213) 463-7939.

EDITING rooms in Santa Monica. Fully equipped w/transfer facilities. Flatbed or standard uprights available. RAMSGATE FILMS (213) 395-8007.

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PROFESSIONAL CAMERA REPAIR TECHNICIAN. Victor Duncan, Inc. has openings in Dallas for professional camera repair technicians. Interested applicants should have a practical background in camera mechanics and optics. VDI offers a complete employee benefit package and excellent working conditions. Salary commensurate with experience. Call Frank Marasco collect in Dallas, (214) 369-1165.

IMAGE DEVICES INC. has immediate openings for camera/optical technicians, electronic technicians, rental and sales personnel, and super secretaries. Professional 16/35mm film and/or video experience ESSENTIAL. Openings in both our Miami and Atlanta offices. Enormous growth potential for career oriented, energetic non-smoker. Salary commensurate with experience. Call toll free (800) 327-5181, resume to Image Devices—Miami, 1825 NE 149 St., Miami, FL 33181, or Image Devices—Atlanta, 1651 Phoenix Blvd., Atlanta, GA 30349, (404) 996-0000.

MAJOR MIDWEST FILM PRODUCTION HOUSE has immediate opening for qualified 16/35 editor. Please send resume to AMERICAN CINEMATOGRAPHER, #1839.

WANTED

HONEY WAGON & large grip truck with generator (212) 246-8484 KEN RICH.

PHOTOSONICS 16-1BAC magazines, (any size) control boxes for same, any extras. RICHARD FISH (415) 457-1985.

STEENBECK 8-plate wanted. 1973 or later model desired. STEVE JONES, (212) 781-7208 NYC.

NAGRA/SOUND/FILM EQUIPMENT WANTED. will trade 50's or Antique jukeboxes. (714) 536-3224 ROGER MENDE, Box 549, Huntington Beach, CA 92648.

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BIRNS & SAWYER pays top dollar for used equipment. Sell or consign, we'll move it faster at top dollar return for you. How? We take less profit and keep the price down. Nagra, Arriflex, Mitchell, Angenieux, whatever else you have. Give us a call (213) 466-8211 Bill Sutphin or come in: 1026 No. Highland Ave., Hollywood, CA 90038.

WANTED: 20-120 zoom lenses, Mitchell R-35 packages, Arri 35mm prime lenses, 8mm Zeiss lenses, Arri 35BL blimp for 25-250, any long lens for Arri, O'Connor 100C and Worrall heads, lighting and grip, dollies, cranes, 35BL camera packages, etc. Image Devices will buy your used equipment regardless of condition. We buy outright or display your gear for consignment sale with no fee. For the best deal, call now: Toll free number; (800) 327-5181, IMAGE DEVICES INC., 1825 NE 149 St., Miami, FL (305) 945-1111, or IMAGE DEVICES INC., 1651 Phoenix Blvd., Atlanta, GA (404) 996-0000.

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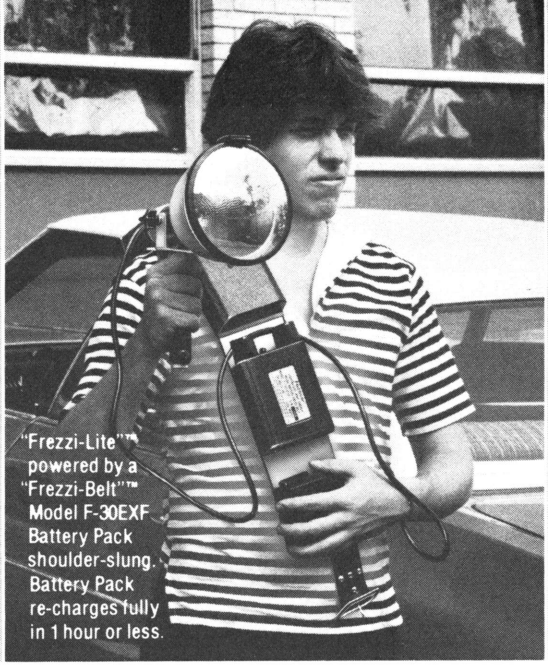
"Frezzi-Lite"™ in hand-held use. Shows detail of rugged metal support bracket. Dichroic filter lock-down screw at top.



"Frezzi-Lite"™ powered by a "Frezzi-Belt"™ Model F-30EXF Battery Pack shoulder-slung. Battery Pack re-charges fully in 1 hour or less.

High-luminance reflector in "Frezzi-Lite"™ gives brighter illumination. Efficiently cooled socket and proper contact design provide long bulb life.

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"Frezzi-Lite"™ 100w, 150w, 250w, 350w. Portable Camera Lights

For video/TV and film/ciné—from the world-famous company that sets the standards.

Operate with true one-hand control of "on-off" lightswitch and focusing thumbwheel. Small: 6.8 inches (172.7mm) without dichroic filter, 8 inches (203.2mm) with dichroic filter, front-to-back; 5.7 inches (145mm) reflector diameter. Lightweight: 14 ounces (400g). Optional easily-removable/attachable "swing-away" dichroic filter. Standard tungsten-halogen 3400°K bulbs. Beam Angles: 20° spot, 40° flood. Lighthead tilts up or down as necessary, locks tightly and holds angle. Permanently-attached 5 foot (1.52m) long power cable terminates in standard plug connector.

Operates "hand-held" with its own removable heavy-duty ribbed-plastic-covered handle or mounts securely on lightstand, or mounts on portable video or film (ciné) cameras with optional "Frezzi-Lite™" Camera Mounting Brackets manufactured by Frezzolini®.

Rugged, reliable metal construction. Professionally adaptable for all portable lighting applications.

Portable Power: "Frezzi-Lite™" Models FL-250 (150w, 250w or 350w) and FL-100 (100w) operate from lightweight, powerful "Frezzi-Belt™" Battery Packs, other styles of "Frezzi™" Battery Packs & matching "Frezzi™" Chargers.

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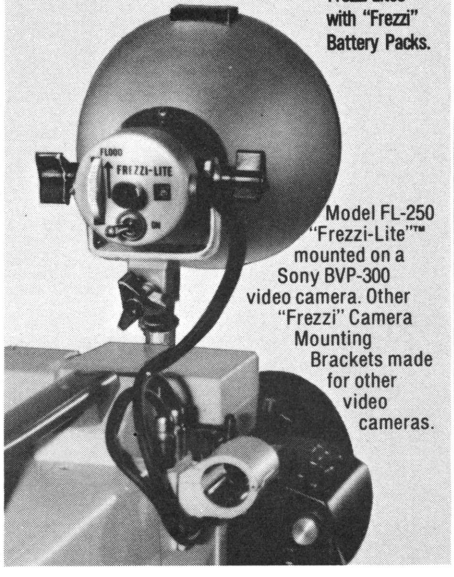
"Frezzi-Lite"™ on "Frezzi-Flex"™ ciné camera with a "Frezzi"™ Camera Mount Bracket. "Frezzi"™ Brackets made for other ciné cameras.



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Model FL-250 "Frezzi-Lite"™ mounted on a Sony BVP-300 video camera. Other "Frezzi" Camera Mounting Brackets made for other video cameras.

"Frezzi-Lite"™ securely mounts on a "Frezzi"™ Lightstand and other standard lightstands.

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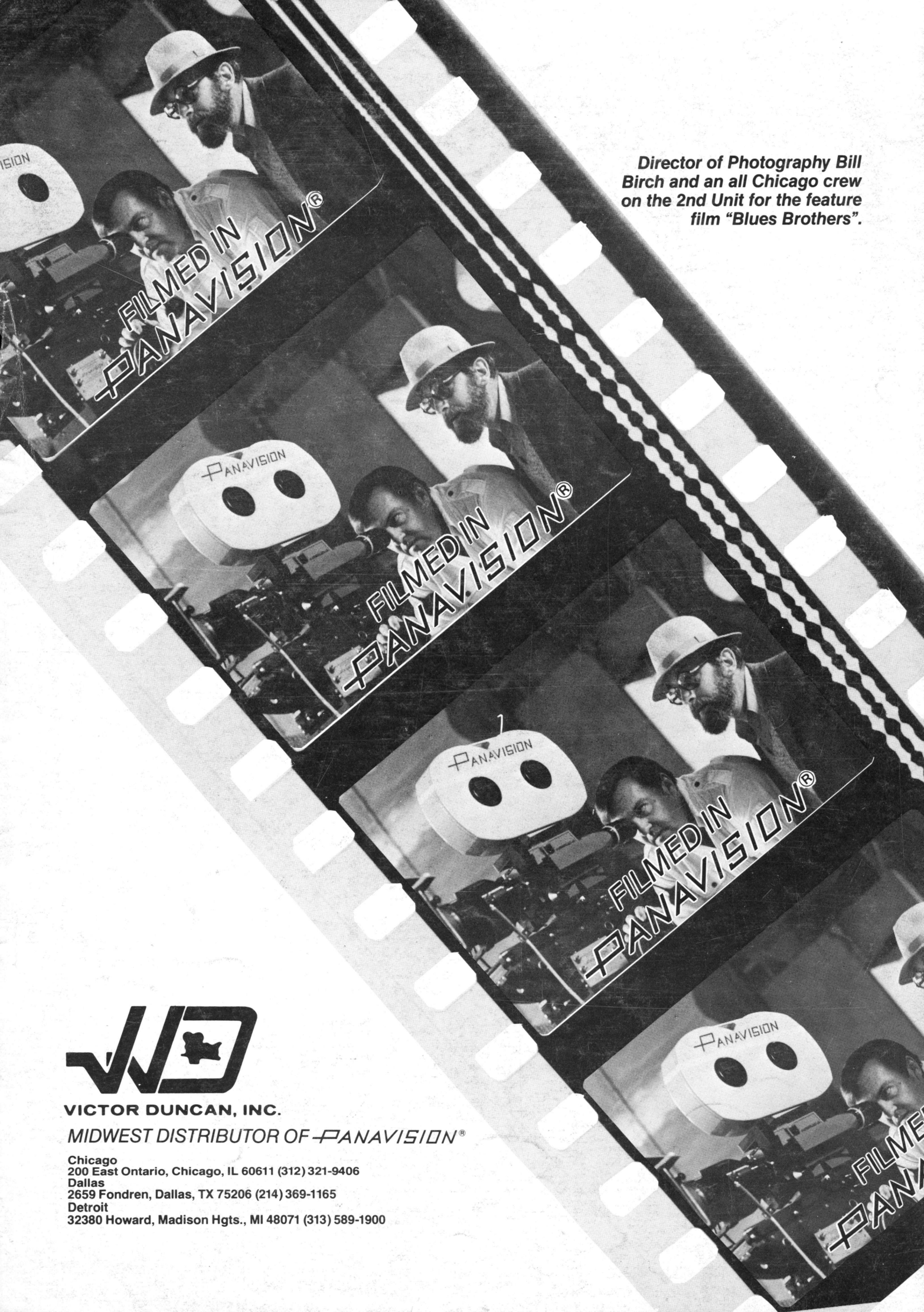

Director of Photography Bill Birch and an all Chicago crew on the 2nd Unit for the feature film "Blues Brothers".

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